Exhibit A

UNITED STATES DISTRICT COURT
NORTHERN DISTRICT OF CALIFORNIA
SAN FRANCISCO DIVISION

IN RE: TFT-LCD (FLAT PANEL) ANTITRUST LITIGATION	Master File No. C07-1827 SI MDL No. 1827
This Document Relates to: DELL INC. and DELL PRODUCTS L.P., Plaintiffs, v. SHARP CORPORATION *et al.* Defendants	

EXPERT REPORT OF PROFESSOR DENNIS W. CARLTON

February 23, 2012

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I. QUALIFICATIONS, CASE DETAILS, ASSIGNMENT, AND SUMMARY OF OPINIONS

A. QUALIFICATIONS

1. I am the David McDaniel Keller Professor of Economics at the Booth School of Business of The University of Chicago. I received my A.B. in Applied Mathematics and Economics from Harvard University and my M.S. in Operations Research and Ph.D. in Economics from the Massachusetts Institute of Technology. I have served on the faculties of the Law School and the Department of Economics at The University of Chicago and the Department of Economics at the Massachusetts Institute of Technology. I specialize in the economics of industrial organization. I am co-author of the book *Modern Industrial Organization*, a leading text in the field of industrial organization, and I also have published over 100 articles in academic journals and books. In addition, I serve as Co-Editor of the *Journal of Law and Economics*, a leading journal that publishes research applying economic analysis to industrial organization and legal matters; serve on the Editorial Board of *Competition Policy International*, a journal devoted to competition policy; and serve on the Advisory Board of the *Journal of Competition Law and Economics*. I have also served as an Associate Editor of the *International Journal of Industrial Organization* and *Regional Science and Urban Studies*, and on the Editorial Board of *Intellectual Property Fraud Reporter.*

2. In addition to my academic experience, I served as Deputy Assistant Attorney General for Economic Analysis, Antitrust Division, U.S. Department of Justice from October 2006 through January 2008. I also served as a Commissioner of the Antitrust Modernization Commission, created by Congress to evaluate U.S. antitrust laws. I have served as a consultant to the Department of Justice and Federal Trade Commission on the Horizontal Merger Guidelines, as a general consultant to the Department of Justice and Federal Trade Commission on antitrust matters, and as an advisor to the Bureau of the Census on the collection and interpretation of economic data.

3. I also am a Senior Managing Director of Compass Lexecon, a consulting firm that specializes in the application of economics to legal and regulatory issues and for which I

served as President (of Lexecon) for several years. I have provided expert testimony before various U.S., state and federal courts, the U.S. Congress, a variety of state and federal regulatory agencies and foreign tribunals. My curriculum vitae, which includes a list of my testifying experience, is attached as Exhibit 1.

B. Case Details

1. Allegations

4. Plaintiffs, consisting of certain purchasers of Thin-Film-Transistor – Liquid Crystal Display (TFT-LCD) panels or finished products containing those panels, allege that Defendants "formed a cartel," which "agreed on prices, agreed to limit production, and agreed to manipulate the supply of TFT-LCD panels and products so that prices remained artificially high."[1] For purposes of evaluating these allegations, the Court certified classes of direct and indirect purchasers of TFT-LCD panels.

2. Plaintiffs and Defendants

5. The current litigation stems from the claims of Direct Action Plaintiffs (DAP) who are not members of the direct and indirect purchaser classes.[2] The following Plaintiffs and Defendants are parties to this particular case.

(a) Description of the Plaintiff

6. Dell offers a range of products including notebook PCs and desktop PCs

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1 Order Granting in Part and Denying in Part Direct Purchaser Plaintiffs' Motion for Class Certification, *In re: TFT-LCD (Flat Panel) Antitrust Litigation*, MDL No. 1827, March 28, 2010 (hereinafter, *DPP Order*) at 3.

2 The DAP group consists of ATS Claim, LLC (ATS), AT&T Mobility and AT&T Inc. (AT&T), Best Buy Co., Inc., Best Buy Purchasing LLC, Best Buy Enterprise Services, Inc., Best Buy Stores, L.P., Best Buy China Ltd., and Magnolia Hi-Fi, Inc. (Best Buy), Costco Wholesale Corporation (Costco), Dell Inc. and Dell Products L.P. (Dell), Eastman Kodak Company (Kodak), Electrograph Systems, Inc. and Electrograph Technologies, Corp. (Electrograph), MetroPCS Wireless, Inc. (MetroPCS), Motorola, Inc. (Motorola), Nokia Corporation and Nokia Inc. (Nokia), SB Liquidation Trust (SB Trust), Alfred H. Siegel (Siegel), Sony Electronics Inc. and Sony Computer Entertainment America LLC (Sony), Target Corporation (Target), Sears, Roebuck and Co. and Kmart Corporation (Sears), Old Comp Inc. (Old Comp), Good Guys, Inc. (Good Guys), RadioShack Corporation (RadioShack), Newegg Inc. (Newegg), TracFone Wireless, Inc. (TracFone).

(b) Description of the Defendants[3]

7. AU Optronics Corporation (AUO) was created in 2001 by the merger of Acer Display Technology, Inc., and Unipac Electronics. During the 2001-2006 period, AUO manufactured, sold, and distributed TFT-LCD panels. AUO sold and distributed TFT-LCD panels in the United States through AU Optronics Corporation America (f/k/a Acer Display Technology America, Inc.) AUO merged with TFT-LCD panel maker Quanta Display in October 2006.

8. Chi Mei Optoelectronics Corporation (CMO), Chi Mei Corporation (CMC), CMO Japan (formerly International Display Technology, "ID Tech"), CMO USA (formerly International Display Technology USA), Nexgen Mediatech, Inc. (Nexgen), and Nexgen Mediatech USA, Inc. (Nexgen USA) sold TFT-LCD panels and/or finished products throughout the 2001-2006 period. In 2009, CMO announced that it would merge with Innolux Display Corp. and TPO Displays Corp. The merger was completed in 2010, and Innolux, the surviving entity, was re-named Chimei Innolux Corporation.

9. Epson Imaging Devices Corporation (EIDC) was formed in October 2004 as a joint venture between Seiko Epson Corporation (Seiko Epson) and Sanyo Electric Co., Ltd. The joint venture was known initially as Sanyo Epson Imaging Devices Corporation. In December 2006, Seiko Epson bought the outstanding shares from Sanyo Electric Co., Ltd. and renamed the entity EIDC. EIDC and its predecessor Sanyo Epson Imaging Devices Corporation manufactured and sold display modules containing TFT-LCD panels to customers in the United States, including sales through Epson Electronics America (EEA), a wholly-owned, indirect subsidiary of Seiko Epson.

10. HannStar first commenced manufacture of a limited number of types and sizes of TFT-LCD panels in 2000 with substantial production beginning in 2001. During the 2001-2006 period, HannStar principally manufactured and sold TFT-LCD panels for monitors and notebooks. In 2005, HannStar also began selling limited volumes of TFT-LCD finished products, some of which were shipped to addresses in the United States.

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3 A list of alleged co-conspirators can be found in the Complaint, March 12, 2010 (hereinafter, *Dell Complaint*).

11. Sharp Corporation (Sharp) of Japan manufactured and sold both TFT-LCD panels and finished products in the United States throughout the 2001-2006 period. Its subsidiary, Sharp Electronics Corporation, was responsible for the sales and marketing of TFT-LCD panels and finished products in the United States.

12. Toshiba Corporation (Toshiba) manufactured TFT-LCD panels until March 2002 and marketed TFT-LCD panels until March 2003. In April 2002, Toshiba and Matsushita Electric Industrial Co. Ltd. combined their TFT-LCD manufacturing assets to form Toshiba Matsushita Display Technology Co., Ltd. (TMD).[4] In 2006, Toshiba combined with Panasonic Corporation (formerly known as Matsushita Electric Industrial Co., Ltd. and Hitachi Displays to form IPS Alpha Technology, which concentrated on large TFT-LCD panels for televisions and in which Toshiba held a minority interest. During the 2001-2006 period, Toshiba, and then TMD, manufactured and sold TFT-LCD panels to customers in the United States exclusively through Toshiba's subsidiary Toshiba America Electronic Components, Inc. (TAEC). Toshiba Corporation manufactured and sold finished product monitors and notebooks during the 2001-2006 period. Those products were sold exclusively in the United States through Toshiba's subsidiary Toshiba America Information Systems (TAIS).

C. Assignment

13. I have been asked by counsel for the Defendants to assess whether the alleged cartel successfully raised the prices of some or all TFT-LCD panels above what those prices would have been in the absence of the alleged cartel, that is, above the "but-for prices." To do so, I apply standard economic theory—much of which is described in my textbook (co-authored with Jeffrey Perloff) *Modern Industrial Organization*—to the TFT-LCD industry and to the nature of the alleged cartel activities to determine whether the alleged cartel was likely to have successfully raised panel prices above their but-for levels. I also assess whether available data on panel prices and quantities support a claim that the alleged cartel successfully raised TFT-LCD panel prices above their but-for levels. As part of this assignment, I have been asked to provide an alternative estimate of damages, based on an economically appropriate econometrics model.

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4. In 2009, TMD was renamed "Toshiba Mobile Display Co., Ltd."

14. Each DAP has retained one or more economic experts to provide opinions on questions of liability and damages.[5] For the purposes of this report, I have also been

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[5] Expert Report of Dr. Helen Jenkins, *In RE TFT-LCD (Flat Panel) Antitrust Litigation, Nokia Corporation and Nokia Inc., v. AU Optronics Corporation et al*., December 19, 2011 (hereinafter, *Jenkins Report*); Expert Report of Mohan Rao, Ph.D., *Dell Inc. and Dell Products L.P., v. Sharp Corporation et al.*, December 15, 2011 (hereinafter, *Rao Report*); Rule 26 Report of John M. Connor, Ph.D., *Dell Inc. v. Sharp Corporation et al.*, December 15, 2011 (hereinafter, *Connor Report*); Expert Report of B. Douglas Bernheim, Ph.D. Concerning *Motorola Mobility, Inc., In RE TFT-LCD (Flat Panel) Antitrust Litigation, Motorola Mobility, Inc, v. AU Optronics Corporation et al*, December 15, 2011 (hereinafter, *Bernheim Report*); Expert Report of David P. Stowell, *In RE TFT-LCD (Flat Panel) Antitrust Litigation, AT&T Mobility LLC, AT&T Corp., AT&T Services, Inc., Bellsouth Telecommunications, Inc., Pacific Bell Telephone Company, AT&T Operations, Inc., AT&T Datacomm, Inc., Southwestern Bell Telephone Company, vs. AU Optronics Corporation et al.*, December 21, 2011 (hereinafter, *Stowell Report*); Expert Report of Gareth Macartney, Ph.D., *In the matter of Eastman Kodak Company v. Epson Imaging Devices Corporation et al.*, December 15, 2011 (hereinafter, *Macartney Report*); and Expert Report of Adam K. Fontecchio, Ph.D., Concerning *Motorola Mobility, Inc., In RE TFT-LCD (Flat Panel) Antitrust Litigation, Motorola Mobility, Inc, v. AU Optronics Corporation et al*, December 15, 2011 (hereinafter, *Fontecchio Report*).

Deposition of Mohan Rao, Ph.D., *In re: TFT-LCD (Flat Panel) Antitrust Litigation,* January 26, 2012 (hereinafter, *Rao Depo.*); Deposition of B. Douglas Bernheim, Ph.D., *re: TFT-LCD (Flat Panel) Antitrust Litigation,* January 30-February 1, 2012 (hereinafter, *Bernheim Depo.*); Deposition of Helen Jenkins, Ph.D., *re: TFT-LCD (Flat Panel) Antitrust Litigation,* February 3, 2012 (hereinafter, *Jenkins Depo.*); Deposition of David P. Stowell, *re: TFT-LCD (Flat Panel) Antitrust Litigation,* February 8, 2012 (hereinafter, *Stowell Depo.*); Deposition of John M. Connor, Ph.D., *re: TFT-LCD (Flat Panel) Antitrust Litigation,* February 8, 2012 (hereinafter, *Connor Depo.*); Deposition of Gareth Macartney, Ph.D., *re: TFT-LCD (Flat Panel) Antitrust Litigation,* February 10, 2012 (hereinafter, *Macartney Depo.*).

I also rely on materials cited or produced by other Plaintiff Experts' reports. *See* Expert Report of Janet S. Netz, Ph.D., *In re: TFT-LCD (Flat Panel) Antitrust Litigation*, MDL No. 1827, May 25, 2011 (hereinafter, *Netz Report*); Expert Reply Report of Janet S. Netz, Ph.D., *In re: TFT-LCD (Flat Panel) Antitrust Litigation*, MDL No. 1827, August 22, 2011 (hereinafter, *Netz Reply Report*); Expert Report of Kenneth Flamm, Ph.D., *In re: TFT-LCD (Flat Panel) Antitrust Litigation*, MDL No. 1827, May 25, 2011 (hereinafter, *Flamm Report*); Reply Expert Report of Kenneth Flamm, Ph.D., *In re: TFT-LCD (Flat Panel) Antitrust Litigation*, MDL No. 1827, August 29, 2011 (hereinafter, *Flamm Reply Report*); Expert Report of Edward E. Leamer, Ph.D., *In re: TFT-LCD (Flat Panel) Antitrust Litigation*, MDL No. 1827, May 25, 2011 (hereinafter, *Leamer Report*); Reply Expert Report of Edward E. Leamer, Ph.D., *In re: TFT-LCD (Flat Panel) Antitrust Litigation*, MDL No. 1827, August 29, 2011 (hereinafter, *Leamer Reply Report*);Expert Report of William S. Comanor, Ph.D., *In re: TFT-LCD (Flat Panel) Antitrust Litigation*, MDL No. 1827, May 25, 2011 (hereinafter, *Comanor Report*); Expert Reply Report of William S. Comanor, Ph.D., *In re: TFT-LCD (Flat Panel) Antitrust Litigation*, MDL No. 1827, August 22, 2011 (hereinafter, *Comanor Reply Report*).

asked to assess the economic models used and the conclusions reached by Dr. Mohan Rao and Dr. John Connor.[6]

15. My report does not address any effects of the alleged cartel on the prices of finished products that incorporate TFT-LCD panels (*e.g.,* computer monitors, notebook computers, televisions, mobile phones). I understand that analysis of the effect of the alleged cartel on finished product prices is the subject of Professor Edward Snyder's expert report in this matter.

16. To carry out this assignment, I have relied on my experience as an economist who has spent more than 35 years studying the nature of competition, including the results of attempts by competitors to form cartels to restrict output and raise prices. I, or my staff at my direction, have reviewed depositions taken and reports filed in this matter; documentary evidence produced in this matter; and other documents including academic literature, reports produced by third parties, and government filings by Defendants and other firms. I, or my staff at my direction, have also studied data produced by Defendants, other firms, and third parties on prices, quantities, profits, costs, capacity, production, and other economic variables.

17. The materials that I and my staff have relied on in the preparation of this report are listed in Exhibit 2. This includes backup materials produced by each Plaintiff Expert, as listed in Exhibit 2, and the expert report from Professor Jerry A. Hausman.[7] In addition, Exhibit 2 includes all materials that I relied on for the reports I produced in the indirect purchases (IPP) and direct purchaser (DPP) class actions related to the alleged TFT-LCD cartel.[8]

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6 *Rao Report* and *Connor Report*.

7 Expert Report of Professor Jerry A. Hausman, *In RE TFT-LCD (Flat Panel) Antitrust Litigation, Nokia Corporation and Nokia Inc., v. AU Optronics Corporation et al.*, February 23, 2012 (hereinafter, *Hausman Report*).

8 Expert Report of Dennis W. Carlton, *In re: TFT-LDC (Flat Panel) Antitrust Litigation: Direct Purchaser Class Action*, July 22, 2011 (hereinafter, *Carlton DPP Report*); Expert Report of Dennis W. Carlton, *In re: TFT-LDC (Flat Panel) Antitrust Litigation: Indirect Purchaser Class Action*, July 28, 2011 (hereinafter, *Carlton IPP Report*); Sur-Reply Report of Dennis W. Carlton*, In re: TFT-LDC (Flat Panel) Antitrust Litigation: Indirect Purchaser Class Action*, September 6, 2011 (hereinafter, *Carlton IPP Sur-Reply Report*); Sur-Reply Report of Dennis W. Carlton, *In re: TFT-LDC (Flat Panel) Antitrust*

18. For my work in this matter, Compass Lexecon has billed my time at $1,250 per hour, and its compensation does not depend on the outcome of this matter. I have been assisted by staff at Compass Lexecon in the preparation of this report. The opinions expressed here reflect the information available to me at this time. I reserve the right to revise my opinions if additional information makes such revisions appropriate.

D. Summary of Opinions

19. My conclusions in this matter are summarized as follows:

- There are at least three categories of TFT-LCD panels that are distinct in their characteristics, exhibit notably different price paths, and have markedly different documentary records of communications among Defendants.
    - Large panels used for TVs;
    - Panels used for computer monitors and notebook computers;
    - Small panels used for mobile phones and other small devices.
- The documentary record of communications among defendants cannot establish the existence of significant overcharges. Rather, a careful study of TFT-LCD industry conditions and empirical evidence on prices, costs, and margins is required.
- The TFT-LCD industry and the alleged cartel exhibit many economic characteristics known to hinder cartel success in elevating prices significantly.
- Straightforward empirical evidence on TFT-LCD prices, quantities, and capacity utilization point to non-cartel-based, demand-side explanations for periods of rising prices ("price humps").
- Plaintiff Expert Dr. Rao's econometric model, when properly adjusted to cover the relevant time period and a more representative set of TFT-LCD panels yields

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Litigation: Direct Purchaser Class Action, September 12, 2011 (hereinafter, *Carlton DPP Sur-Reply Report*); Deposition of Dennis W. Carlton, PhD., *In re: TFT-LDC (Flat Panel) Antitrust Litigation*, August 17, 2011 (hereinafter *Carlton Depo.*).

very small or negative damages. In any case, his model is too unreliable to support an inference of significant positive overcharges:

- Although the Dell complaint indicates that the conspiracy lasted until "December 11, 2006, at a minimum,"[9] Dr. Rao stops his damages period at the end of 2004, noting that "[d]uring 2005 and 2006, the model does not indicate persistent overcharges."[10] It is not valid to change the damages period because the results do not show persistent overcharges; using the full time period reduces Dr Rao's estimated overcharge to one percent.
- Dr. Rao also applies arbitrary rules to drop several panels from his percentage overcharge calculation; including them yields a negative overcharge estimate.

- I also construct my own, more appropriate econometric model of overcharges and find:
  - Reliable econometric models of overcharges can be constructed only for mobile phone panels and notebook panels, not for all small panels combined, monitor panels, or TV panels;
  - None of my preferred econometric models finds a statistically significant effect of the alleged cartel on prices. To the extent the model estimates an overcharge, it is too small to be distinguished statistically from random price fluctuation;
  - If I am asked to assume the existence of a successful cartel and to use an econometric model to form the best available prediction of the cartel's effect on prices, my model yields an overcharge prediction of approximately 0.4% for notebook computers;

9 *Dell Complaint*, ¶96.

10 *Rao Report*, ¶110. To be clear in the report, if I am referring to Dr. Rao's abbreviated damages period, I refer to "Dr.Rao's damages period." When I use the term damages period without referring to Dr. Rao, I define it as January 1999 – December 2006 for consistency across cases (including the DPP and IPP Cases; see *DPP Order* at 34).

- If I am asked to provide an estimated overcharge for monitor panels, my main response is that I do not have a reliable econometric model for those panels on which to base such an estimate. However, I consider my overcharge estimate for notebook computers to be the best available econometric estimate for monitor panels.

20. The remainder of this report develops the factual, theoretical, and empirical bases for these conclusions. Section II provides relevant background on the industry and describes the three broad categories of TFT-LCD panels. Section III focuses on the differences in the price patterns between TFT-LCDs and other types of LCDs, across the three broad categories of TFT-LCDs, and among different types of panels within each broad category. Section IV describes the evidence on the scope of the alleged communications and shows that prices did not adhere consistently to the allegedly agreed upon levels. Section V details the many characteristics of the TFT-LCD industry that are known, as a matter of economic theory, to hinder a cartel's ability to raise prices significantly. Section VI demonstrates that straightforward evaluation of the patterns of prices, quantities, and capacity utilization in the TFT-LCD industry does not point to a cartel-based explanation for observed price increases. Section VII explains why Dr. Rao's overcharge estimates yield implausible results on profitability patterns, including an implication that, but for the alleged cartel, Defendants would have earned substantially negative economic profits for Dr. Rao's damages period. Section VIII explains why the econometric model presented by Dr. Rao cannot reliably support a finding of large, positive overcharges. Section IX presents my econometric model and results. Section X concludes.

II. BACKGROUND

A. Various Types Of LCD Panels

21. An LCD panel is an electronic display device that operates by applying an electrical charge to a layer of liquid crystal, thereby inducing changes in its optical properties. LCD panels are used in a variety of products, including: computer monitors;

notebook computers; flat-panel televisions (TVs); and mobile devices, such as mobile phones, digital cameras and camcorders, and portable electronic games.[11]

22. Early mobile phones used black and white panels, which were mostly Twisted Nematic (TN) or Super-Twisted Nematic (STN) LCD panels, also referred to as Monochromatic STN (MSTN) panels. By 2004, black and white screens on mobile phones had been surpassed by color displays, often using Color STN (CSTN) panels.[12]

23. Both MSTN and CSTN-LCD panels represent "passive-matrix" LCD panels.[13] Over time, these passive-matrix LCD panels were displaced by "active-matrix" LCD panels, the most common being TFT-LCD panels. TFT-LCD panels (initially used for notebook computers) are more expensive and power-hungry than STN-LCD panels, but have greater color depth and purity, faster response time, and greater contrast than STN-LCD panels.[14]

24. Another type of active-matrix technology, Thin Film Diode (TFD), was designed to achieve response times similar to TFTs but with lower cost and power consumption. These characteristics made TFDs more attractive for electronics that require small high-quality screens but are not particularly expensive, such as those used in some digital cameras and mobile phones.[15] However, TFT-LCD panels have the highest performance

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11 www.britannica.com/EBchecked/topic/343093/liquid-crystal-display (February 17, 2012), *site visited* February 17, 2012.

12 CK Chow, "Display Trend – Information Display," January 2005 at 4.

13 Passive matrix technology uses a grid of control wires placed on the front and back glass. Pixels are located at the junctions between the rows and columns of these wires. The matrix then uses one transistor for each row and one for each column. As a result of this structure, residual electrical current can cause "crosstalk" at unselected pixels. With CSTN, the result is a slow-responding display of lower quality images. In contrast, active matrix displays have a transistor built into each pixel, which helps turn the pixels on and off at very fast rates. As a result, active matrix displays they have little to no crosstalk and provide a higher quality image. *See, e.g.,* Jeremy Gurski and Lee Ming Quach (2005), "Display Technology Overview," *Lytica White Paper* at 11-19, and http://support.apple.com/kb/TA21582?viewlocale=en_US (July 28, 2011), *site visited* February 11, 2012.

14 CK Chow, "Display Trend – Information Display," January 2005 at 5.

15 *See* Jeremy Gurski and Lee Ming Quach (2005), "Display Technology Overview," *Lytica White Paper* at 18-19. *See also* http://techon.nikkeibp.co.jp/article/HONSHI/20061117/123921/ (November 17, 2006), *site visited* February 11, 2012.

and are best suited for computer monitors, television screens and other high-end displays.[16]

B. TFT-LCD PANELS

25. All of the commerce at issue in this case is made up of TFT-LCD panels. A TFT-LCD panel is comprised of a layer of liquid crystal encapsulated between two glass substrates. One glass substrate has an array of thin film transistors and circuitry. The other glass substrate has color filters. When stimulated by an electrical charge, liquid crystals change the properties of light passing through the color filters. TFT-LCDs are distinguished from earlier passive matrix technologies by the presence of a transistor at each pixel, the smallest picture element in a panel. Color and brightness at each pixel are electronically adjusted through manipulation of the optical properties of the liquid crystal via the transistor. The total number of pixels in a display determines the resolution; standard names have been adopted for several display resolutions (*e.g.*, 1024 horizontal pixels by 768 vertical pixels are referred as "1024x768" resolution, or "Extended Graphics Array" (XGA) display).[17]

26. A TFT-LCD panel combined with a backlight unit, some electronic circuitry, and other components is referred to as a TFT-LCD "module."[18] A TFT-LCD panel may be sold as a panel, a module, or embodied in a further-finished product such as a computer monitor. My analysis deals with the sales of either panels or modules and I will refer to both of these forms of the product as "panels."

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16 GSMArena.com, a site that gathers information on mobile phone handsets, shows very few mobile phones with TFD displays (21 products). A similar search of "TFT" under phone specifications results in more than 3,000 products. *See* http://www.gsmarena.com/results.php3?sFreeSearch=yes&sFreeText=tfd (February 13, 2012), *site visited* February 13, 2012, and http://www.gsmarena.com/results.php3?sFreeSearch=yes&sFreeText=tft (February 13, 2012), *site visited* February 13, 2012.

17 *See, e.g.*, Yasuhiro Ukai (2007), "TFT-LCD Manufacturing Technology - Current Status and Future Prospect," IEEE Xplore; Expert Report of Shukri Souri, Ph.D., *In re: TFT-LCD (Flat Panel) Antitrust Litigation*, *No. 3:07-md-01827 (N.D. Cal)*, February 23, 2012 (hereinafter, *Souri Report*), ¶33; and www.plasma.com/classroom/what_is_tft_lcd.htm (February 18, 2012), *site visited* February 18, 2012. TFT-LCD panels are also known active matrix LCD panels.

18 *See* Yasuhiro Ukai (2007), "TFT-LCD Manufacturing Technology - Current Status and Future Prospect," IEEE Xplore at 2; and *Souri Report*, ¶68.

27. A TFT-LCD panel is an intermediate good. That is, panel manufacturers do not sell panels directly to end consumers but instead to other manufacturers that use the panels as an intermediate input into final goods, such as televisions, notebook computers, computer monitors and mobile phones, which are in turn sold to end consumers. For transactions pertinent to this case, panels are sold or transferred to different types of customers: directly to Plaintiffs who manufacture other products (whether for input into a finished good or to distributors or resellers to be resold as panels); directly to other Defendants; or transferred within a Defendant firm to be used as an input into further-finished products or for further resale.

C. THREE GENERAL CATEGORIES OF TFT-LCD PANELS

28. In analyzing the TFT-LCD industry and the allegations in this case, it is useful to distinguish between different types of TFT-LCD panels that are put to different uses.[19] For purposes of this report, I find it useful to group TFT-LCD panels into *three broad categories* made up of panels that are clearly distinct in their characteristics and primary manufacturers and, most importantly for the analysis of prices and alleged cartel effects, exhibit distinct pricing patterns. The three product categories are:

- TV panels, which are generally larger than 20” diagonal;
- Monitor/notebook panels, which are generally between 10” and 20” diagonal (although there are examples of notebook panels below 10” and monitor panels over 20”), and
- Small panels used in mobile phones and other small devices.

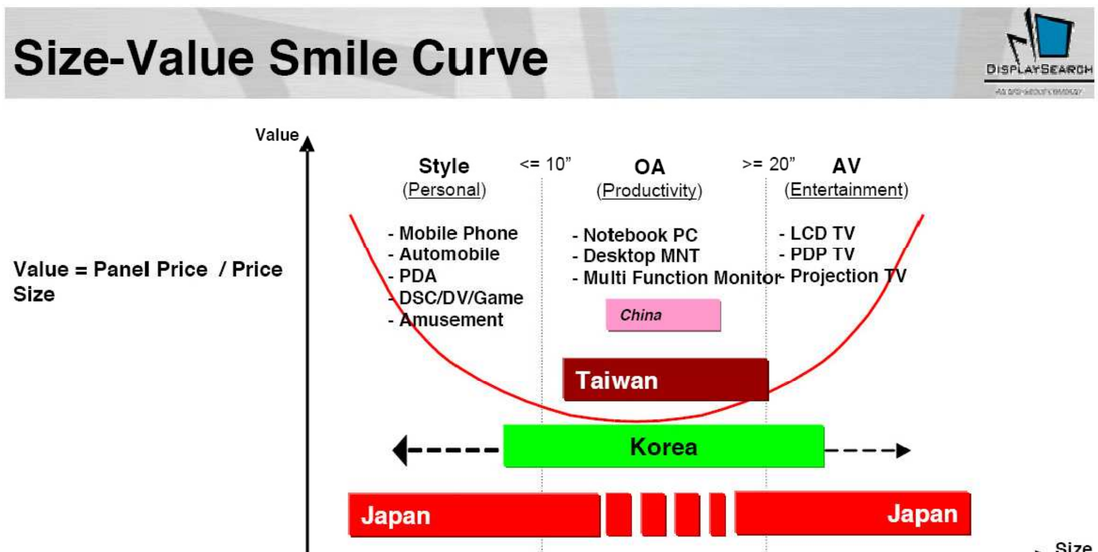
As described in Section IV, below, the evidence on communication between Defendants in this matter also differs between these categories.[20, 21]

19 Defendants’ Expert Dr. Shukri Souri notes that features of TFT-LCD panels differ across applications (*e.g.*, mobile, laptop, desktop and TV) such that TFT-LCD panels designed for one application cannot be substituted into another application. (*Souri Report*, ¶¶53-54.)

20 As I explain below, there are distinctions between products within these broad categories based on application. For example, panels for notebooks and monitors are distinct products with different pricing patterns. For purposes of this report, I group them together in a single category because they are generally produced by the same set of

29. The general categorization of TFT-LCD panels into three categories has been recognized by industry sources, which establish that these three different categories of TFT-LCD panels face a correspondingly wide range of marketplace conditions. Figure II-1, drawn from a DisplaySearch presentation (from 2005), depicts a "smile curve" that lays out some of the differences across the categories of panels:[22]

Figure II-1: General Panel Categorization



Market /Channel	Focus/Few	Open/Many/Disperse	Focus/Few
Competition	Focus	Disperse	Focus but diluting
Brands	Few	Many	Few, but increasing
Brand Loyalty	High	Low	Very High
Main Cost Factor	Brand, Channel & Service	Manufacturing Cost	Brand, Channel & Service

30. As shown in the figure, "value" (measured by panel price/panel size) differs by category of panel, with both small panels (for mobile phones, as well as automotive applications, PDAs and other uses) and larger panels for TVs having greater value per square inch than medium sized panels for monitors and notebooks. In addition, the main

manufacturers and purchased by the same set customers (*e.g.*, Dell) and the evidence on communications among Defendants is similar within each category.

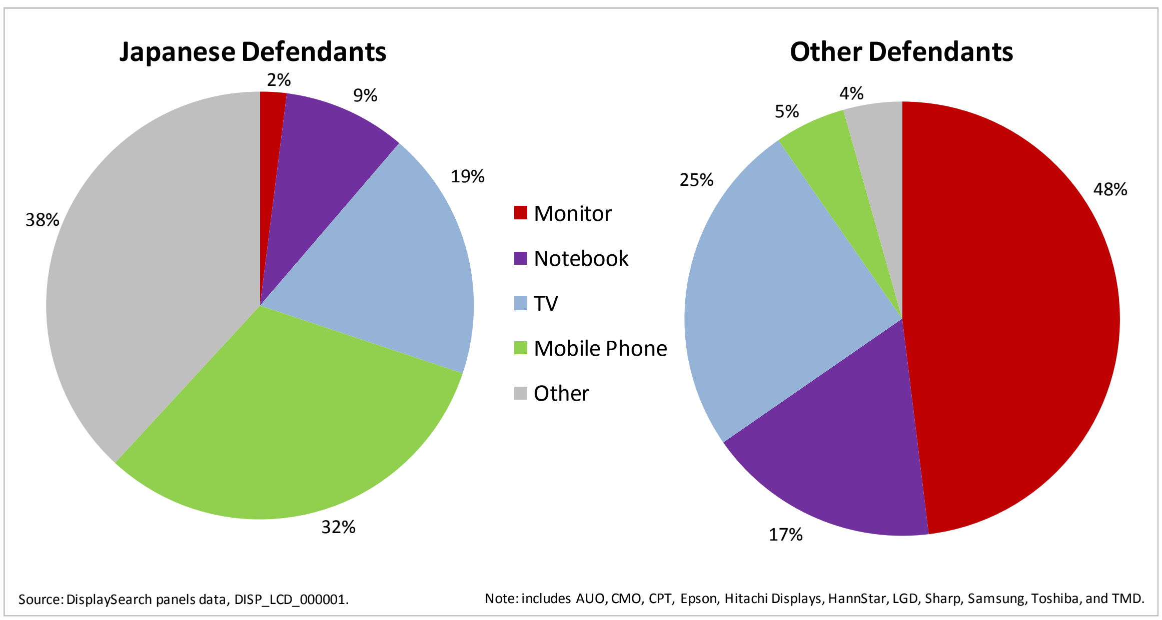
21 The three categories do not cover all TFT-LCD panels. There are other miscellaneous applications such as large panels for public displays. I understand that there are no allegations of communication or price fixing related to these miscellaneous products.

22 Figure drawn from David Hsieh, "Flat Panel Display Market Outlook", Shanghai Intl. Industry Fair, *DisplaySearch*, November 5, 2005 at 31.

producers vary, with Taiwanese and (by the end of the damages period) Chinese producers primarily focusing on the monitor and notebook panels, Korean producers making the whole range of sizes, and Japanese producers primarily focusing on the higher-valued small and large panels. The figure also lists a number of other differences in economic conditions, including the fact that the main cost factors vary by category of panel.

31. Figure II-2, below, provides a further look at the sharp distinctions across producers in terms of panel-mix. For example, as of 2005, nearly two-thirds of revenue for the non-Japanese (primarily Taiwanese and Korean) producers came from monitor and notebook panels, while the Japanese producers received only about 11 percent of their revenue from monitor and notebook panels (with only 2 percent from monitor panels). As explained more fully below, discussions at the "Crystal Meetings," which are at the heart of the Plaintiffs' case, often focused on the monitor/notebook category.

Figure II-2: Share of Revenues by Panel Size, Japanese and non-Japanese Defendants, 2005

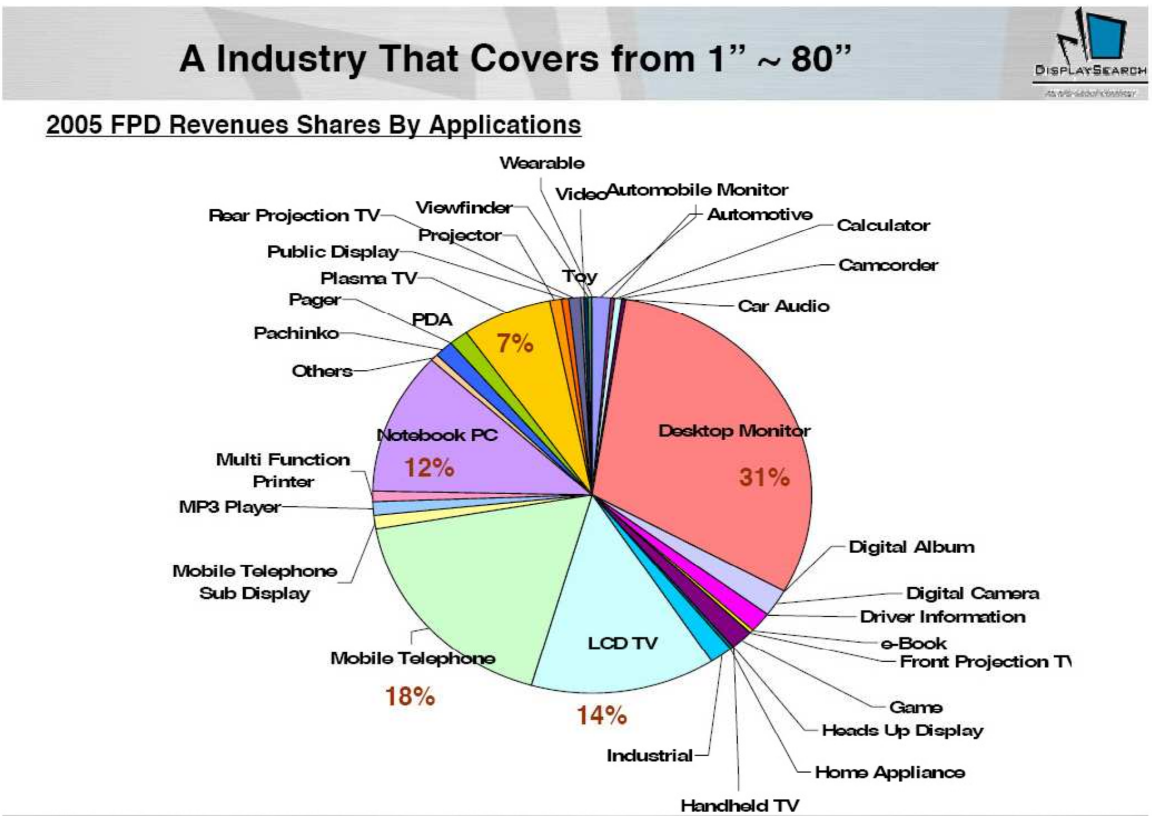


D. DIFFERENTIATION OF TFT-LCD PANELS WITHIN CATEGORY

32. Within the three main categories, panels can be distinguished by several additional characteristics, including detailed application types, an array of sizes and resolutions, and other characteristics.

33. The range of applications for TFT-LCD panels includes not just the major applications discussed above (TVs, monitors/notebooks and mobile phones) but also applications such as portable DVD players, GPS navigation systems, MP3 players, video cameras, digital still cameras, portable medical devices, refrigerators, car displays, and ATM displays. Figure II-3 illustrates the breadth of panel applications in 2005, both for TFT-LCD panels and some alternative types of flat panel displays:[23]

Figure II-3: Distribution of TFT-LCD Panel Sales by Application, 2005



34. Panel sizes and resolutions also do not fall into just a few size and resolution categories. In Defendants' transactions data, I observe sales of over 120 different panel sizes, ranging from less than 1 inch to 82 inches, during the damages period. There are over 25 different display standards and there are well over 300 unique display standard and size combinations.[24]

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23 Figure drawn from David Hsieh, "Flat Panel Display Market Outlook," Shanghai Intl. Industry Fair, *DisplaySearch*, November 5, 2005 at 6.

24 Calculations included in backup materials.

35. Differentiation across panels, however, ranges far beyond size and resolution. Other relevant dimensions of differentiation include viewing angle, contrast, brightness, glare, refresh rates, color quality, response time, cosmetic specifications, "greenness," and thickness.[25] Panel characteristics vary in importance depending on the application. For example, there are important differences in weight, size, and power consumption between monitor and notebook panels. As another example, TFT-LCD panels for TVs generally require higher contrast ratios, wider viewing angles, and faster response times in order to compete with other TV display technologies such as Plasma Display Panel (PDP).[26] Automotive applications require higher tolerances to temperature extremes.[27]

36. In sum, there are a very large number of permutations of panel characteristic. As one illustration of the wide range of panel types available, AUO's transactions data lists more than 800 different types of panels sold, of which more than 500 garnered more than $100,000 in sales each.[28]

E. ENORMOUS CHANGES IN THE TFT-LCD INDUSTRY

37. The wide array of TFT-LCD panels with different characteristics did not all enter the marketplace at the same time. Rather, they have been introduced over time. Indeed, the enormous breadth of TFT-LCD panels that exists today is just one of many significant changes that the TFT-LCD industry has undergone since its inception. In this sub-section, I describe these changes. In Section V, below, I explain more fully why technological change and new product introductions make it unlikely for an alleged cartel to be long-lasting and successful.

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25 *See Fontecchio Report*, ¶¶22-43. *See also*, the general discussion of relevant characteristics in David Hsieh, "LCD Demand, Panels, Substrates All Move from Large to Larger," *DisplaySearch Trends*, Spring 2006; Richard Chu, "Sharp," ING Barings, July 26, 2001 at 13; Deposition of Scott Birnbaum, February 19, 2009, 195:9-23; and Deposition of Joyce Pan, March 9, 2009, 79:8-80:16.

26 *See, e.g.,* http://www.crutchfield.com/S-21PTs4k4ZHh/learn/learningcenter/home/tv_flatpanel.html (February 13, 2012), *site visited* February 17, 2012.

27 *See* Declaration of Michael Blashe (Manager of Application Engineering of Toshiba Electronic Components Inc), June 25, 2009 at 9.

28 Calculations included in backup materials. I define a unique panel in the AUO data using a combination of model number and version number.

38. Since its inception in the early 1990s, the TFT-LCD industry has been characterized by "explosive market growth."[29] During the time period covered by the damages period, new applications for TFT-LCD panels drove this market expansion.[30] Figure II-4 shows total annual panel sales volume and the share accounted for by different applications from 2000 to 2010.[31] Over the 2000-2006 period, total sales of TFT-LCD panels approximately quintupled, with a compound annual growth rate of about 30 percent between 1999 and 2006 (*see* Figure II-4). The importance of different applications shifted over time, with notebook panels, which had dominated sales until 2000, giving way first to monitor panels, and then later to TV panels and small panels for mobile phones. Industry analyst John Matthews describes the trends in applications as follows:[32]

> New applications for these [TFT-LCD and other flat] panels keep being developed, from the original application of flat screens for notebook computers, to the rapid penetration of desktop monitors (displacing traditional cathode ray tube displays), to the LCD TVs that are now invading the consumer television market, to small displays lighting up cell phones, digital still cameras, and personal digital assistants, as well as to large displays such as the light-emitting diodes that are illuminating our cities in a way never seen before.

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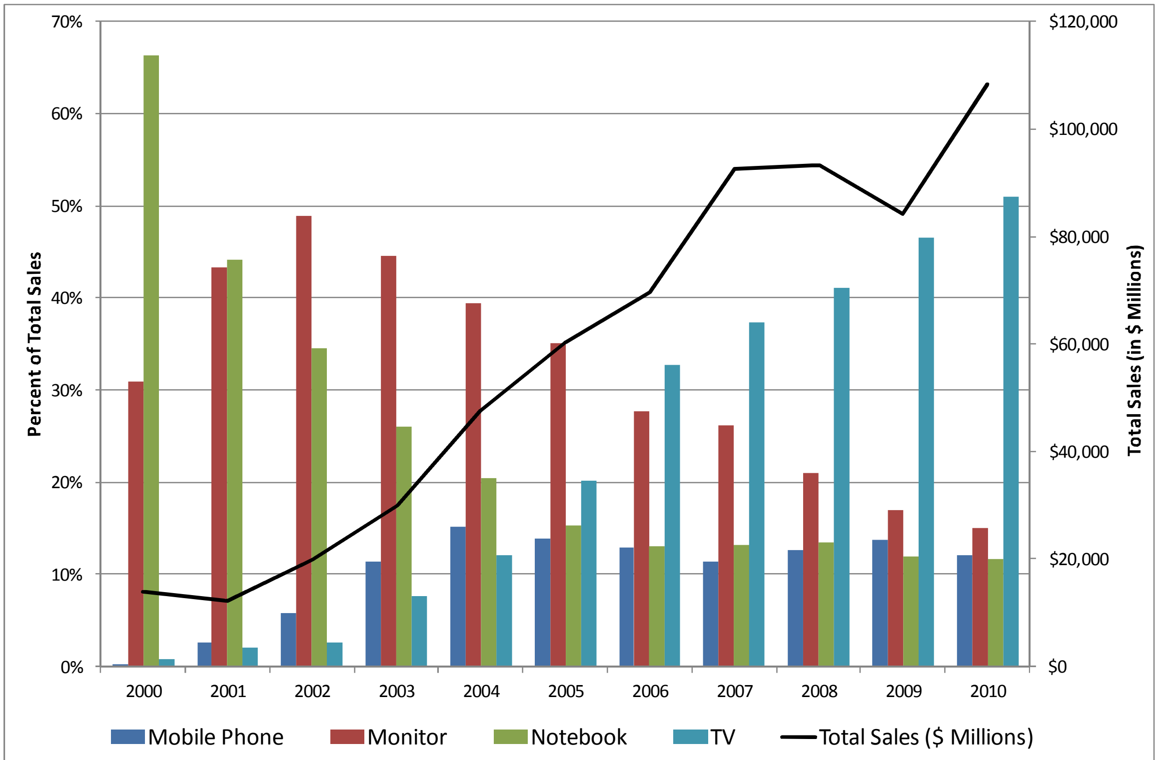
[29] John A. Matthews (2005), "Strategy and the Crystal Cycle," *California Management Review,* 47(2) at 9.

[30] Matthews (2005) at 19.

[31] Figure II-4 excludes other kinds of TFT-LCD panels such as "Automobile Monitor", "Digital Still Camera", "Public Display", and "Other".

[32] Matthews (2005) at 7.

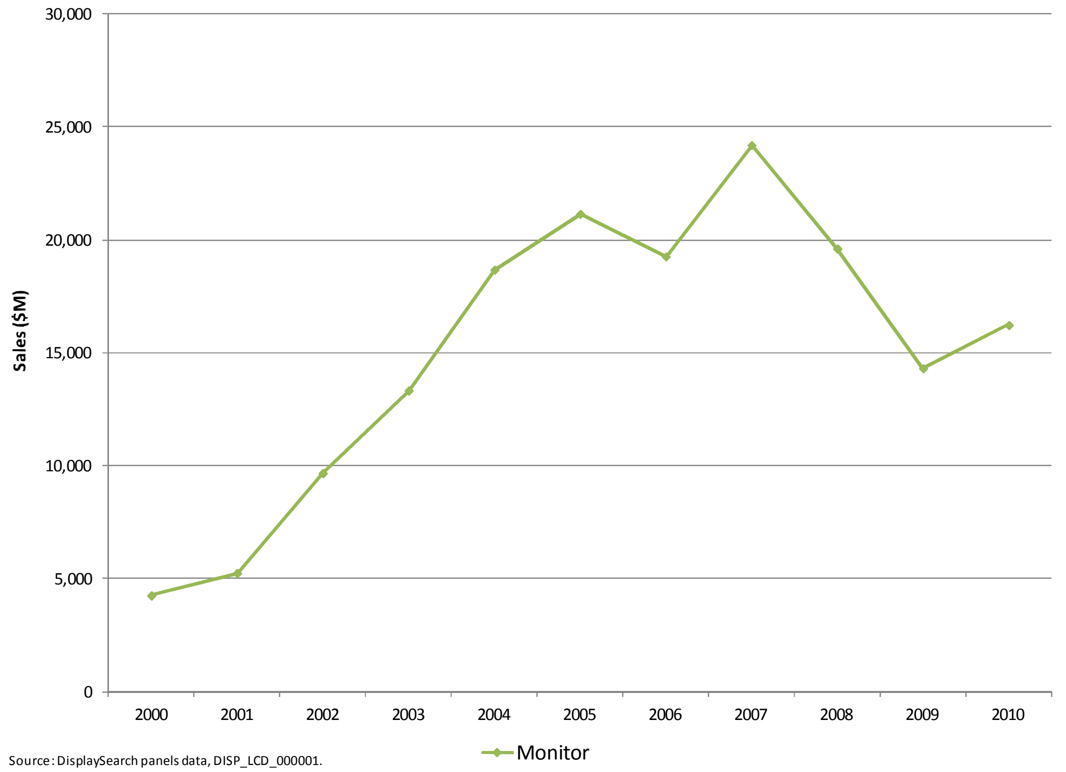
Figure II-4: Annual TFT-LCD Panel Sales, by Application, 2000-2010



Source: DisplaySearch panels data, DISP_LCD_000001.

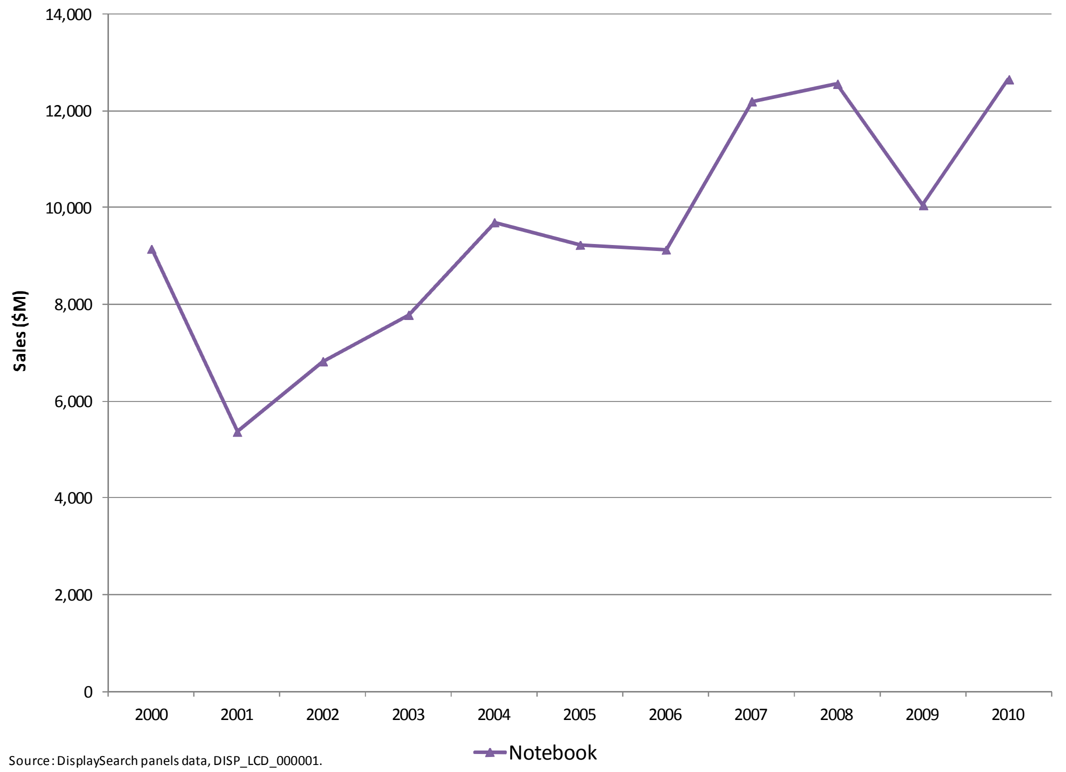
39. The three main categories of TFT-LCD panels grew rapidly, but on sharply different timelines. Panels for notebooks, then monitors, were the first main TFT-LCD products, with over $4 billion in annual sales each for notebooks and for monitors, as early as 2000. Figure II-5 and Figure II-6 show the growth in dollar volume of panels used in monitors and notebooks, respectively, over the 2000 – 2010 period.

Figure II-5: Annual Monitor TFT-LCD Panel Sales, 2000-2010



Source: DisplaySearch panels data, DISP_LCD_000001.

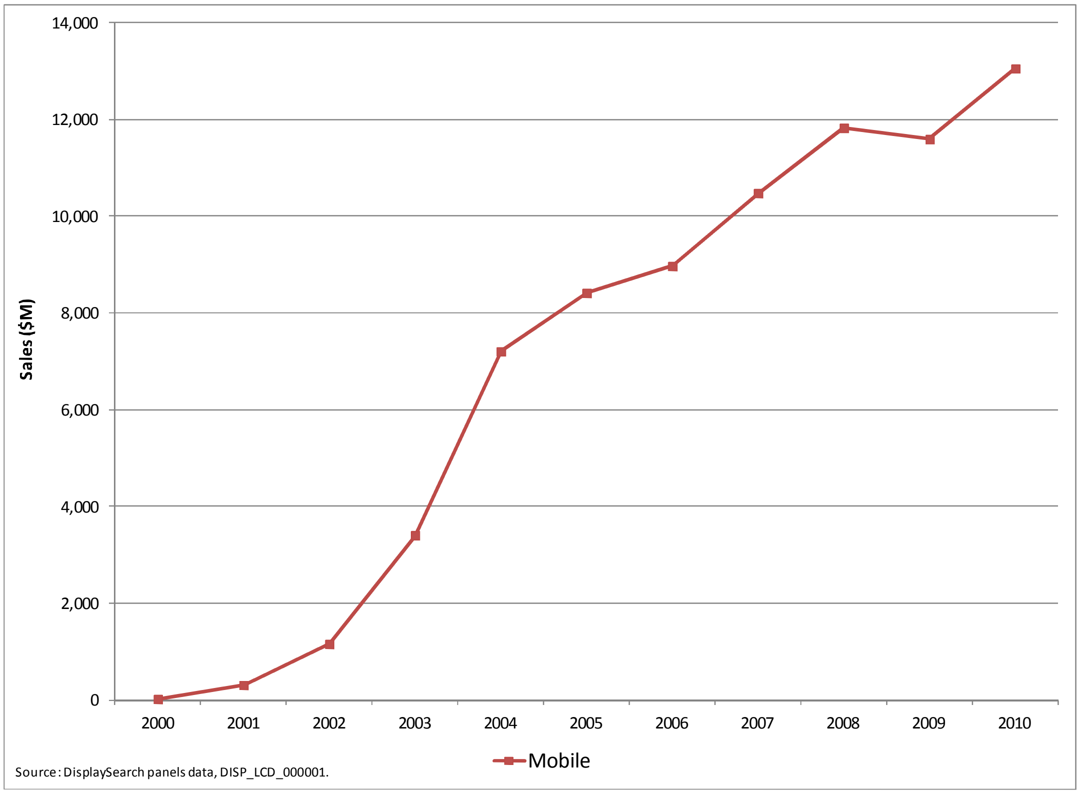
Figure II-6: Annual Notebook TFT-LCD Panel Sales, 2000-2010



Source: DisplaySearch panels data, DISP_LCD_000001.

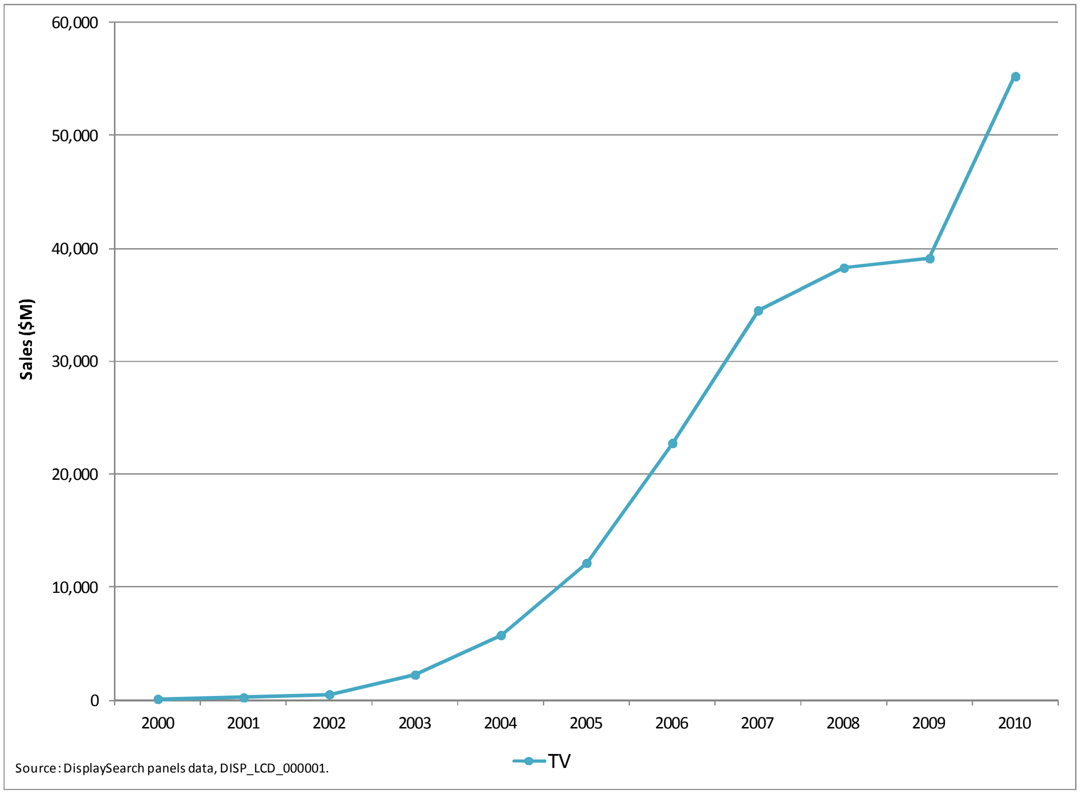
40. Small TFT-LCD panels for mobile phones and other devices were introduced in 2001, but did not experience rapid growth until at least 2003. Figure II-7 shows the growth in small panel dollar sales. The data indicate that TFT-LCD small panels reached approximately $1 billion annual sales in 2002.

Figure II-7: Annual Mobile TFT-LCD Panel Sales, 2000-2010



41. Finally, Figure II-8 shows the growth in TV panel dollar sales. TFT-LCD panels for TVs had minimal sales until 2003, but became a $10 billion per year business by 2005.

Figure II-8: Annual TV TFT-LCD Panel Sales, 2000-2010



42. To a large degree the pace of growth in each application was dictated by the existence of distinct substitute technologies that competed with the TFT-LCD panels in that application. In particular:

- For notebook computers, LCD panels were essentially the only viable option from the outset. Hence, this was the first type of TFT-LCD panel to take off.

- In contrast, as shown in Figure II-9, CRT monitors were sold in greater numbers than TFT-LCD monitors until 2004. Figure II-10 shows that CRT monitors dominated TFT-LCD monitors in terms of dollar sales until 2002.

Figure II-9: Annual Monitor Unit Sales by Technology, 2000-2010

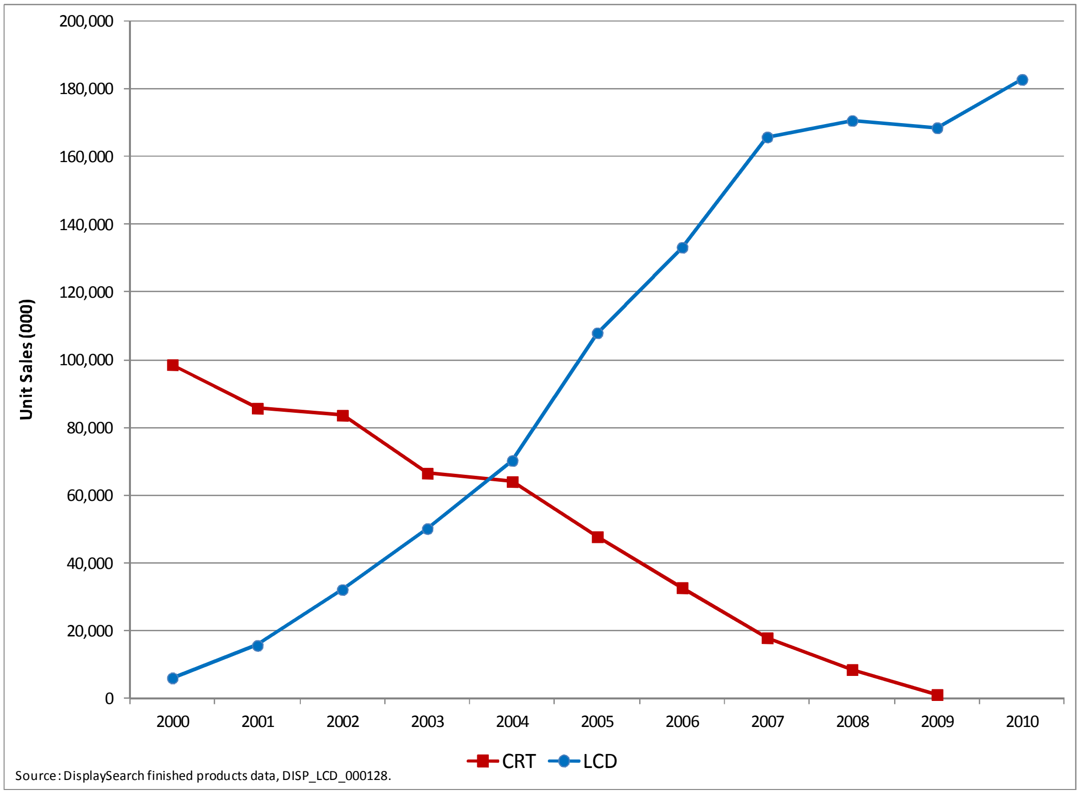
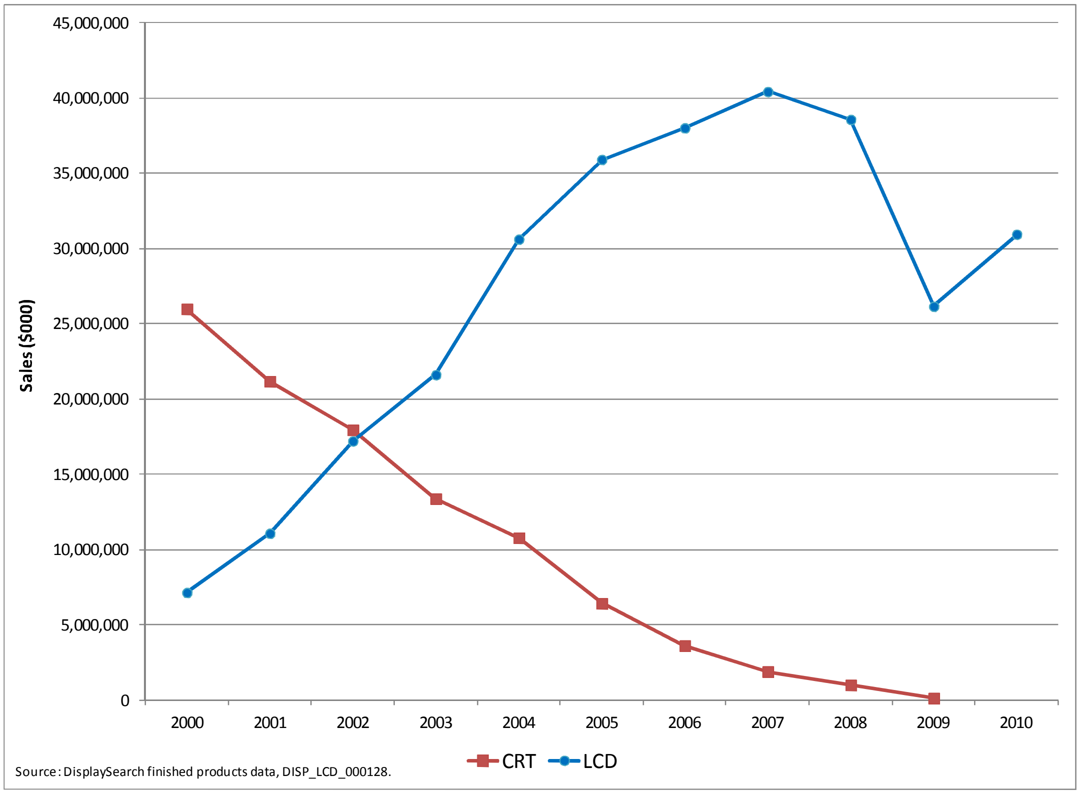
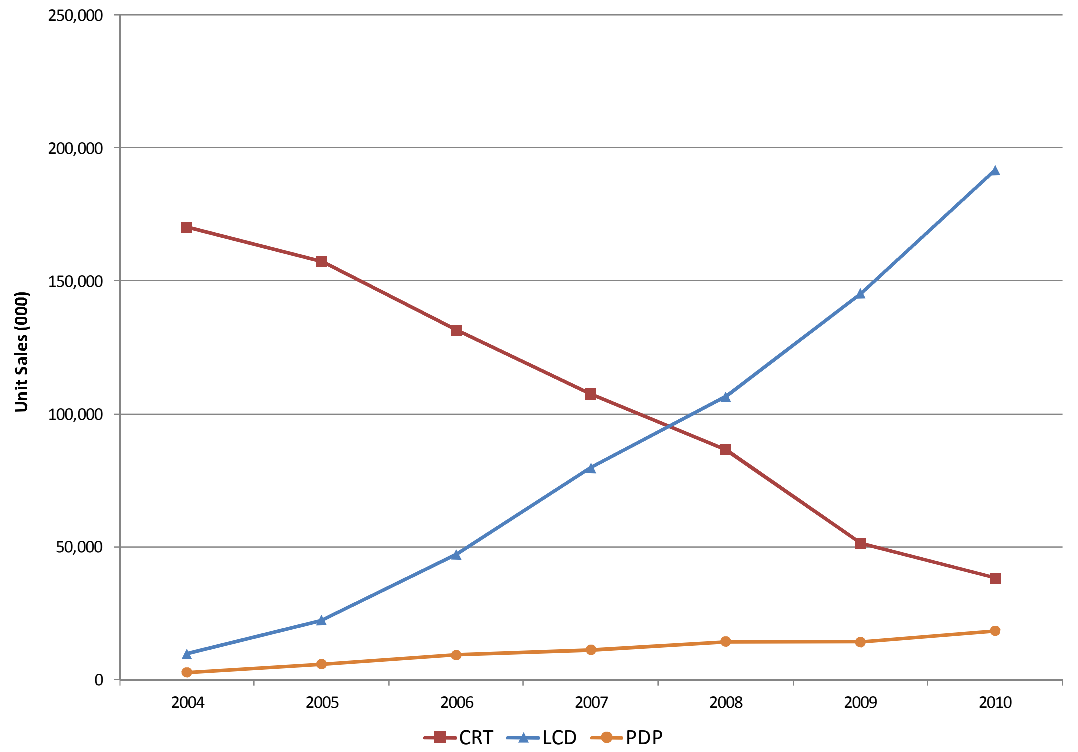


Figure II-10: Annual Monitor $ Sales by Technology, 2000-2010



- In the case of TVs, Figure II-11 and Figure II-12 show that CRTs outsold TFT-LCD panels in terms of units until 2008 and in terms of dollars until 2005, with some competition also from plasma (PDP) displays.[33]

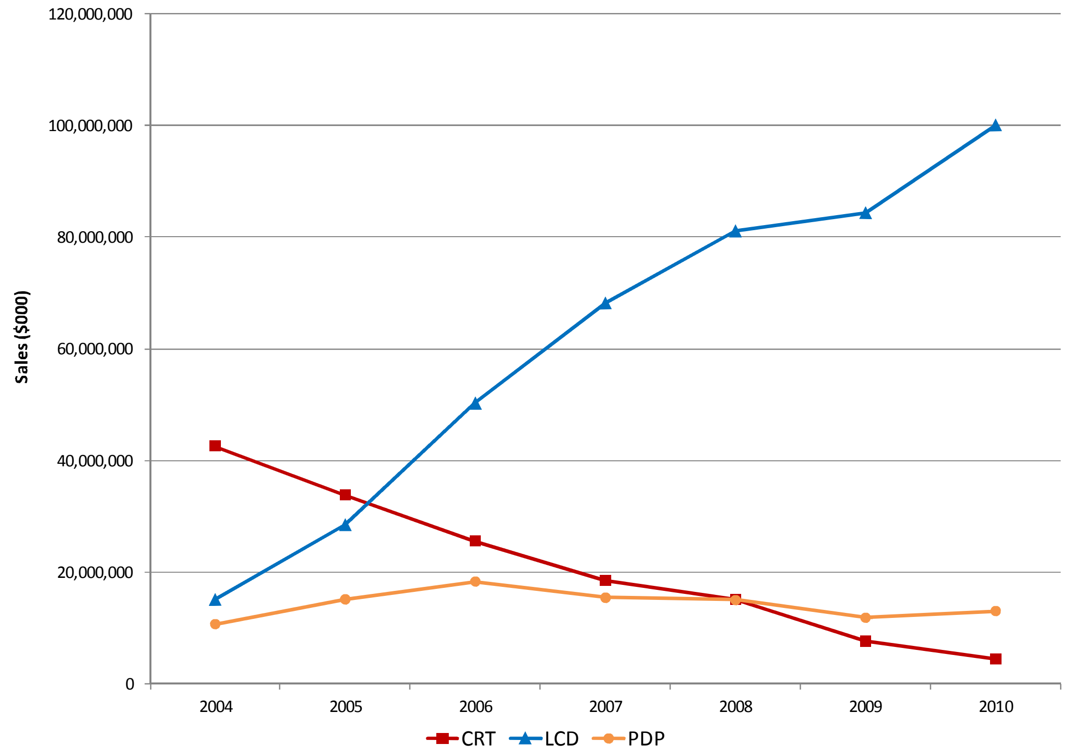
Figure II-11: Annual TV Unit Sales by Technology, 2000-2010



Source: DisplaySearch finished products data, DISP_LCD_000128.

[33] PDPs are the only other technology with significant dollar sales for TV panels, but plasma has never outsold TFT or CRT, in terms of unit sales, in the TV category.

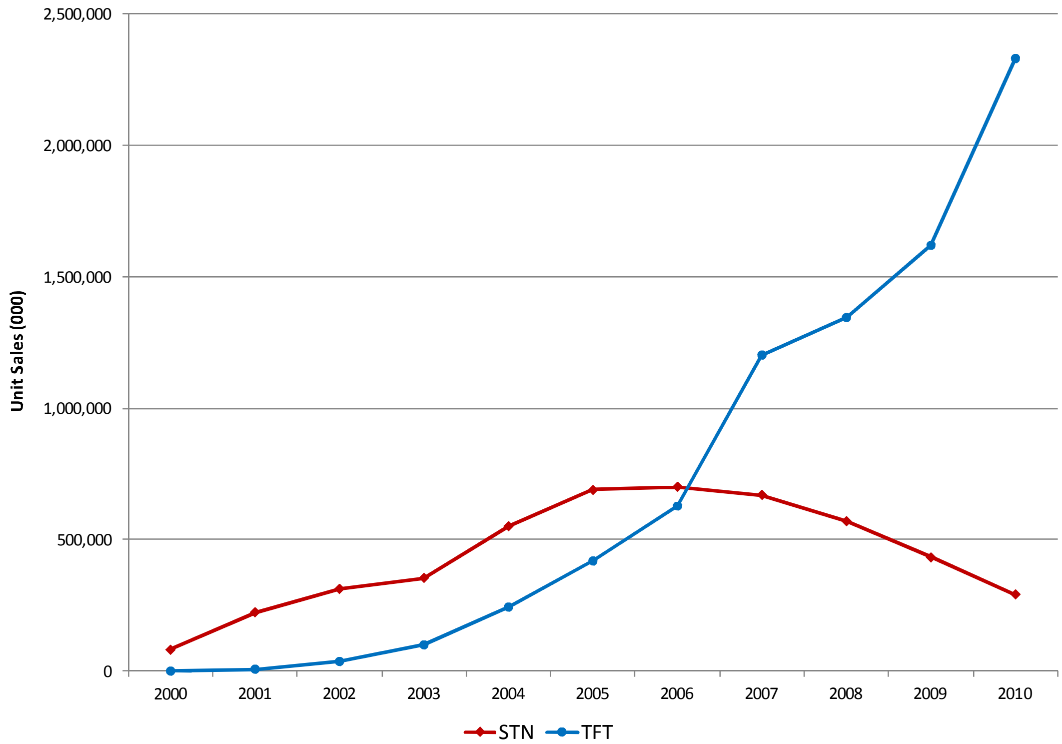
Figure II-12: Annual TV $ Sales by Technology, 2000-2010



Source: DisplaySearch finished products data, DISP_LCD_000128.

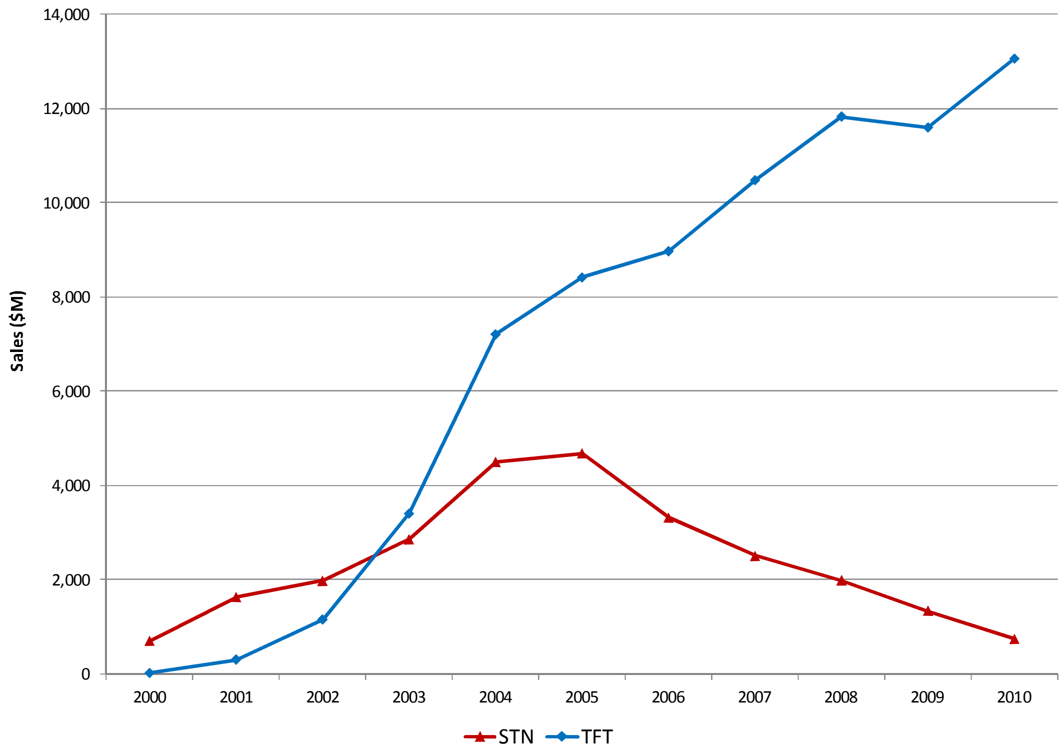
- Finally, Figure II-13 and Figure II-14 show the substitution pattern between STN and TFT-LCD panels used in mobile phones. The data indicate that STN outsold TFT-LCD panels in mobile phones until 2007 in terms of units and until 2003 in terms of dollar sales.

Figure II-13: Annual Unit Sales of Mobile Panels by Technology, 2000-2010



Source: DisplaySearch panels data, DISP_LCD_000001.

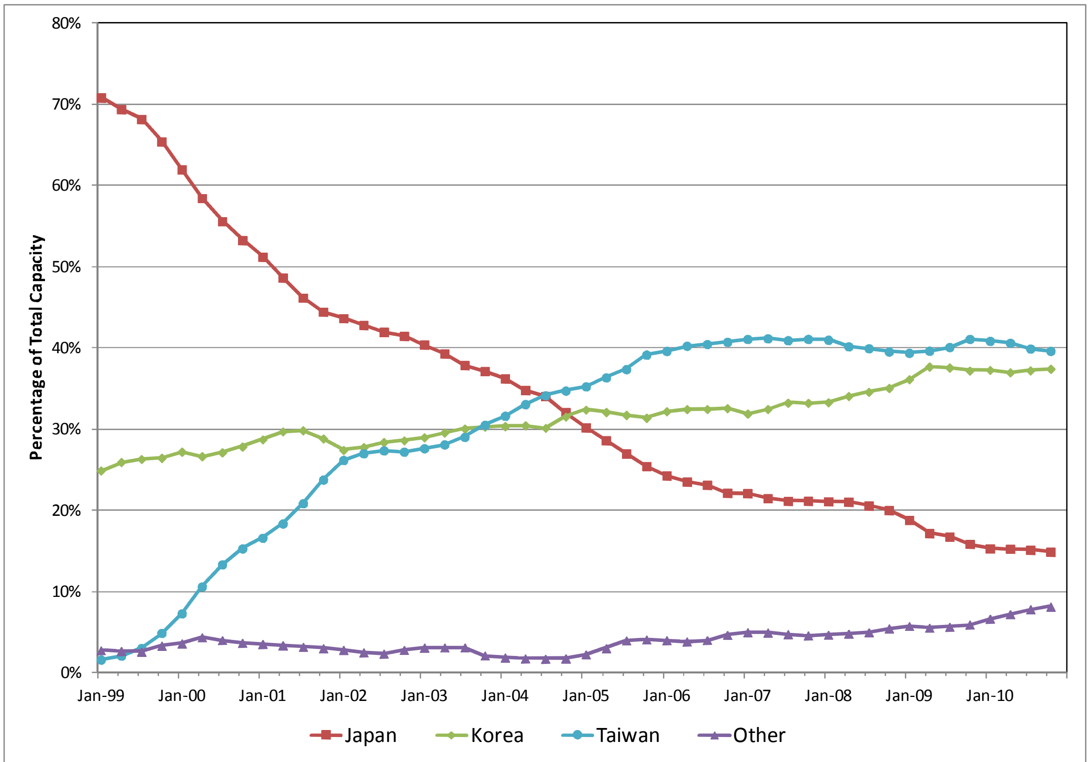
Figure II-14: Annual $ Sales of Mobile Panels by Technology, 2000-2010



Source: DisplaySearch panels data, DISP_LCD_000001.

43. Along with the explosive growth in TFT-LCD panel production and the increasing breadth of applications, the locus of production has shifted. Through 1995, production occurred almost exclusively in Japan. In the mid-1990s, Korean firms—notably LG Display (LGD) and Samsung—entered the industry. Then in the late 1990s, Taiwanese firms, including Chi Mei, Chunghwa, HannStar, and Unipac and Acer Display (the predecessors to AUO) entered. Figure II-15 charts the shift in capacity between different countries.

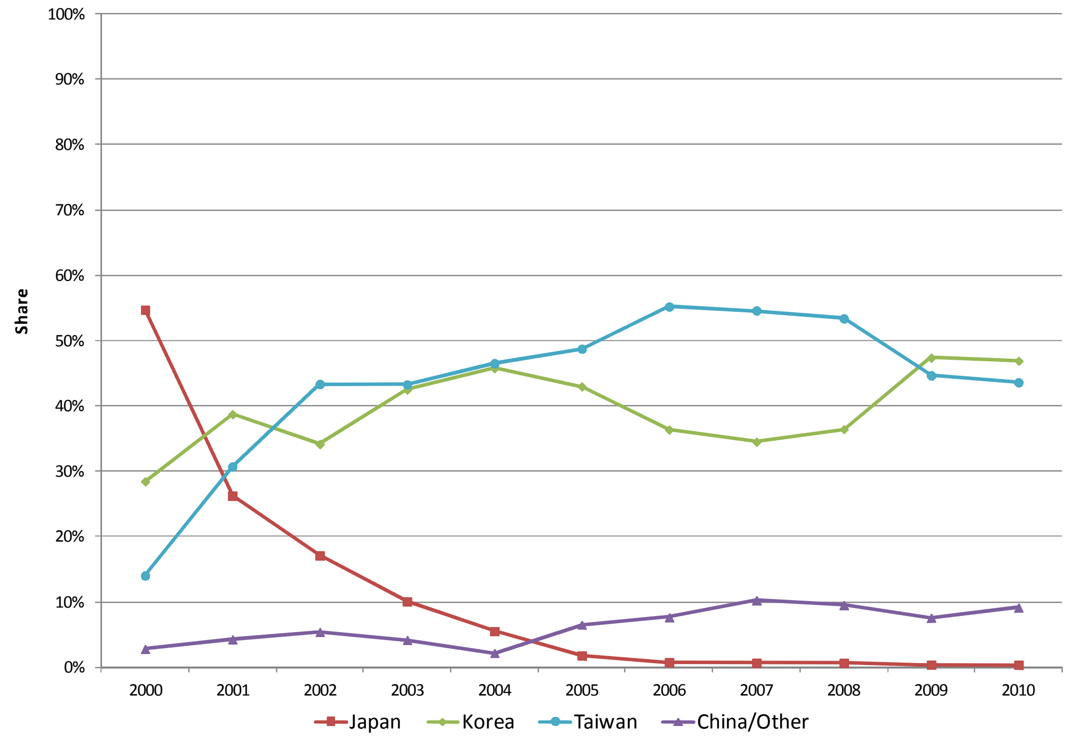
Figure II-15: TFT-LCD Industry Capacity Shares



Source: DisplaySearch capacity data, DISP_LCD_000002.

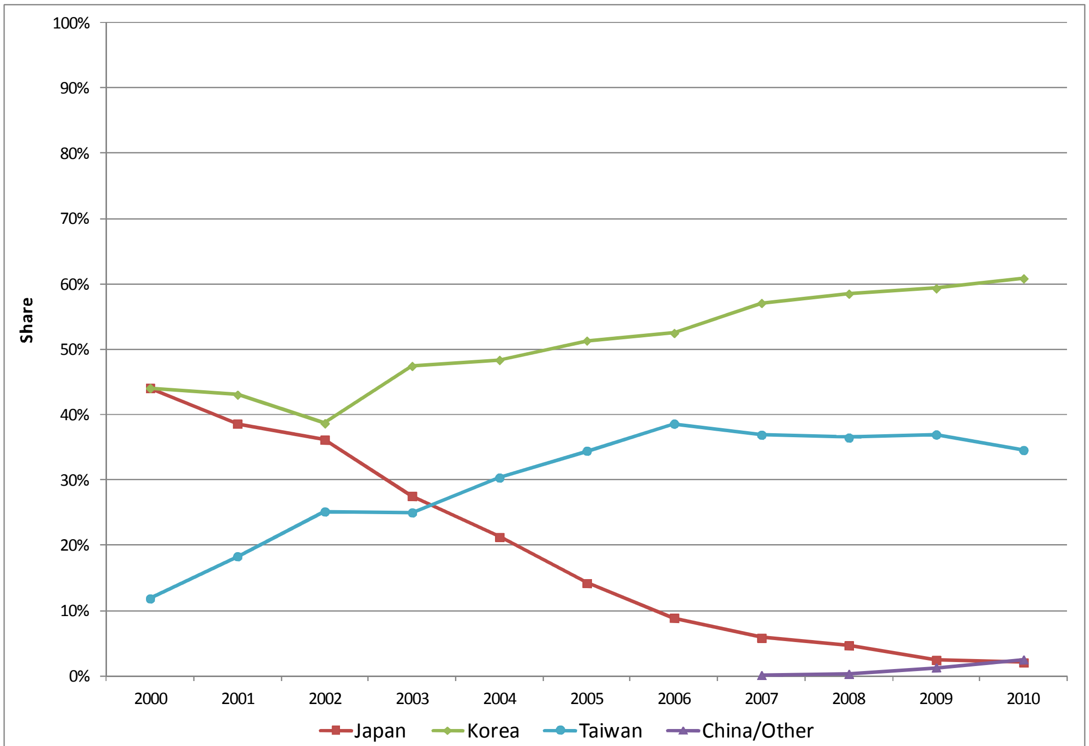
44. The regional shifts in TFT-LCD capacity shares reflect the relative growth in each of the product applications and the changes in the regional distribution of production. For example, Figure II-16 and Figure II-17 show regional sales for monitor and notebook TFT-LCD panels, respectively, which were led by suppliers in Korea and Taiwan. Similarly, as shown in Figure II-18, Korea and Taiwan have been the primary sources for large TFT-LCD panels used in TVs since 2005.

Figure II-16: Annual Monitor TFT-LCD Sales by Region, 2000-2010



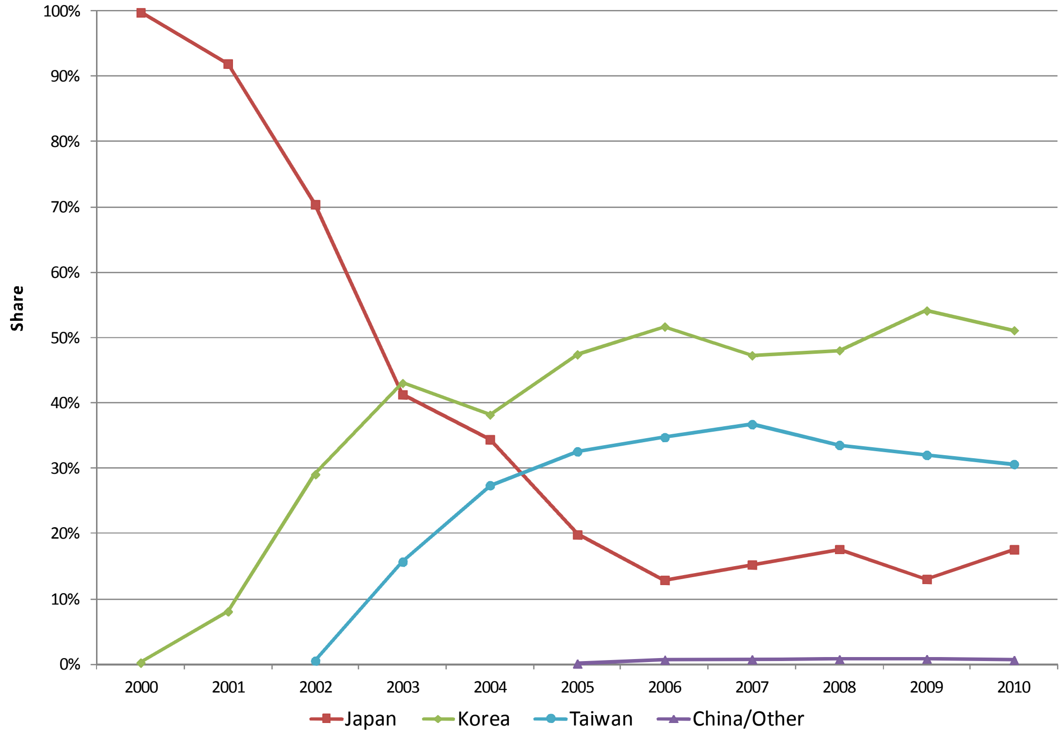
Source: DisplaySearch panels data, DISP_LCD_000001.

Figure II-17: Annual Notebook TFT-LCD Panel Sales by Region, 2000-2010



Source: DisplaySearch panels data, DISP_LCD_000001.

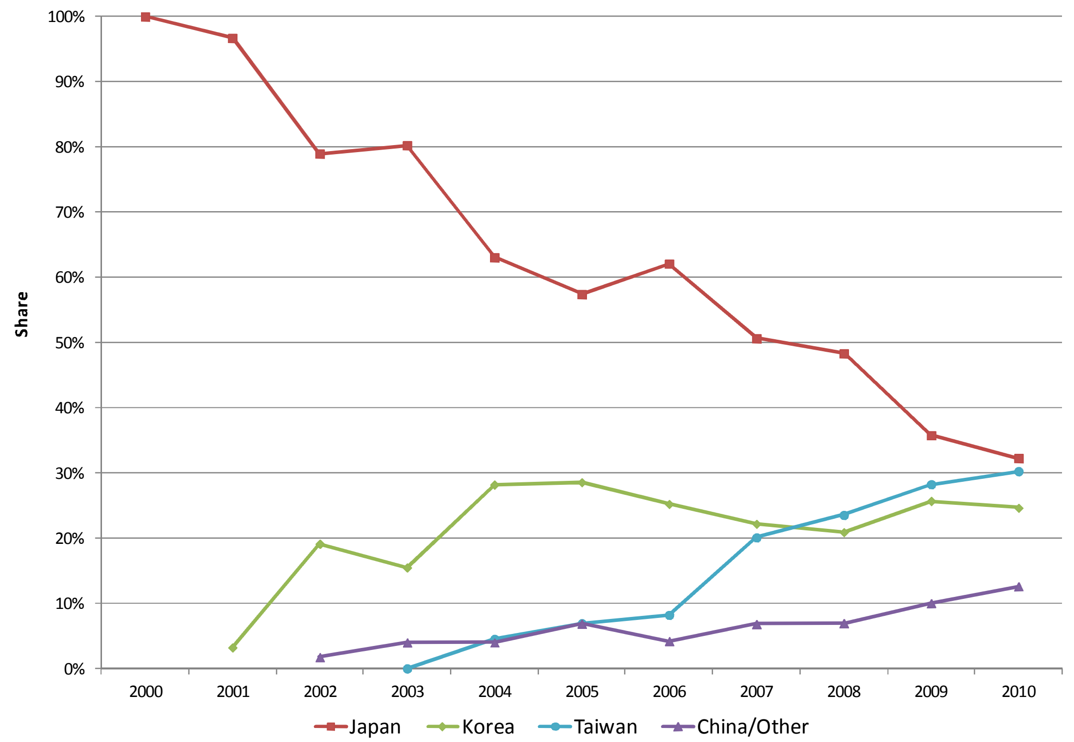
Figure II-18: Annual TV TFT-LCD Panel Sales by Region, 2000-2010



Source: DisplaySearch panels data, DISP_LCD_000001.

45. Figure II-19 shows the growth in TFT-LCD sales for mobile phones by region. Japanese suppliers were the first to produce small panels. Korean suppliers experienced substantial growth in this category in the 2001-2004 period, and Taiwanese suppliers started to grow substantially in the category around 2003. By 2009, Japan, Korea and Taiwan had roughly equal shares of small panel sales.

Figure II-19: Annual Mobile TFT-LCD Panel Sales by Region, 2000-2010

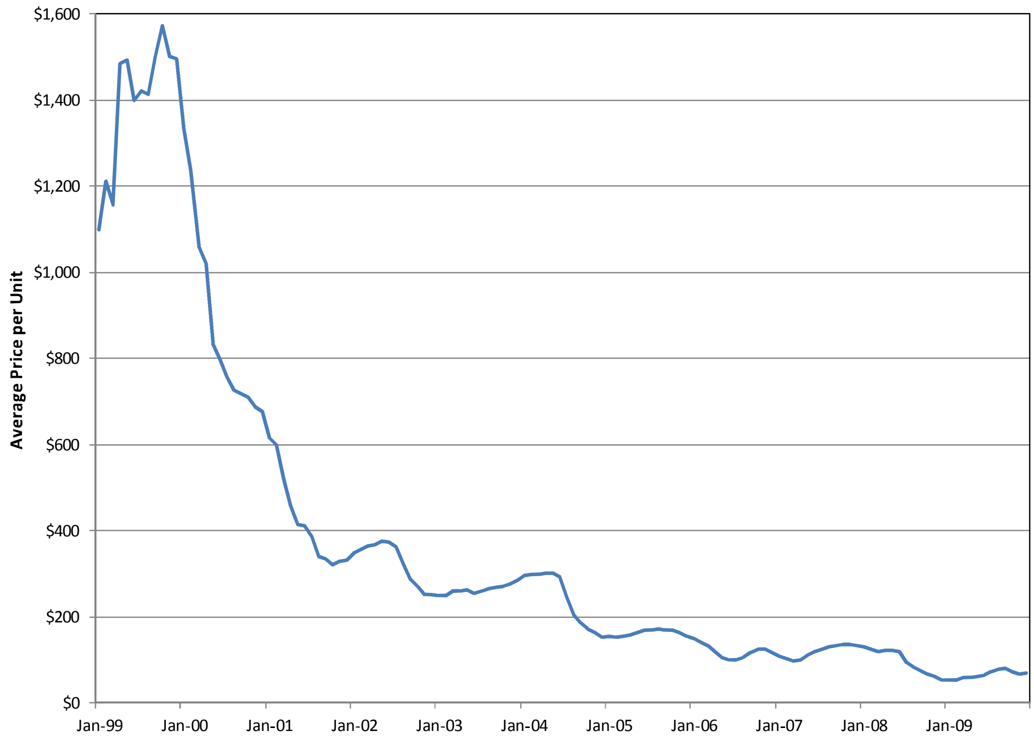


Source: DisplaySearch panels data, DISP_LCD_000001.

F. DECLINING PRICES

46. Throughout the history of the TFT-LCD industry, one feature has been common: rapidly declining prices. Panel prices are characterized by two separate downward trends: (1) the downward price trend of a particular panel (which is priced highest when first introduced with subsequent declines in price) and (2) the downward price trend of all panels over time (meaning new panels tend to be introduced at a lower absolute price than previous models). As one example, the downward price trend for a particular high-selling application/size/resolution (the 17 inch SXGA monitor panel) is illustrated in Figure II-20:

Figure II-20: Monthly Average Panel Price, 17" SXGA Monitor, 1999-2009



Source: Defendants' transaction data.

47. Declining prices have been driven in large part by investments in successive "generations" of fabs, designed to handle successively larger-sized motherglass, which allows more panels and/or panels of larger sizes to be formed from a single sheet. For example, the third generation fabs that were still in substantial use at the start of the damages period could handle motherglass of just over 5 square feet, while seventh generation fabs, which were well established by the end of the damages period, could handle motherglass roughly 10 times larger (more than 50 square feet). As Dr. Connor has acknowledged, as the overall sales have grown and technology has improved—in particular the use of this larger motherglass—manufacturing costs have declined.[34]

[34] *Connor Report,* ¶25. *See also* Jeongsik Lee, Byung-Cheol Kim, Young-Mo Lim (2011), "Dynamic competition in technological investments: An empirical examination of the LCD panel industry," *International Journal of Industrial Organization*, 29:718-728 at 720.

48. To be clear: I am *not* claiming that this pattern of declining prices, on its own, proves the absence of a cartel. However, this pattern of rapidly falling prices is the backdrop against which all assertions and analyses in this case must be assessed. First, when evaluating Dr. Rao's overcharge models (discussed in Section VIII, below), one should keep in mind that the vast majority of the observed "non-cartel" sales—which are used as a benchmark for the prices that would have obtained but-for the alleged conspiracy—occur after 2006, when prices were dramatically lower than during most of the class period. Absent sufficient controls to account for the general pattern of falling prices (perhaps including a measure of cost, an overall time trend, a measure of the elapsed time since each type of panel was introduced, as well as other control variables), Dr. Rao's models may find large overcharges, based simply on the fact that prices were much lower after 2006 than before. Hence, in reviewing those models, it is critical to evaluate whether Dr. Rao has enough appropriate controls to adjust for declining prices, rather than simply attributing higher early prices to cartel effects

49. In addition, as discussed more fully in Section VI, below, rapid declines in price during the period of the alleged cartel are consistent with the large body of economic literature on cartel pricing, which demonstrates that cartels often break down, leading to rapid declines in price.[35] When cartel members cheat on a price agreement, as is often in their economic self-interest to do, prices can rapidly decline. Attempts to maintain a price-fixing agreement will encourage entry which, if it occurs, also can cause the agreement to break down.[36] I note that the rapid price declines during 2000-2001 occurred as firms from Taiwan entered the market and began to build up share.[37]

50. Finally, in Section III, below, I show that the price patterns exhibited by the three main categories of TFT-LCD panels are quite distinct. To observe these price patterns

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35 *See, e.g.*, Margaret E. Slade (1990), "Strategic Pricing Models and Interpretation of Price-War Data," *European Economic Review* 34:524-537 at 534.

36 For the fact that price-fixing agreements that maintain high prices will encourage entry, *see* Yuliya V. Bolotova (2009), "Cartel Overcharges: An Empirical Analysis," *Journal of Economic Behavior & Organization,* 70 at 331. ("[S]etting a high level of cartel price is likely to attract new entrants, which would make collusive actions less profitable.")

37 Consistent with this, Plaintiffs themselves note: "By January of 2000, prices for TFT-LCD Products were falling again. The price decline in this period was substantially influenced by the entry of six new Taiwanese competitors…." (*Dell Complaint,* ¶171.)

requires looking beyond the common downward trend in prices, for example by de-trending the data. Otherwise, the common pattern of falling prices may mask the differences in pricing patterns.

III. THE DISTINCT PRICE PATTERNS ACROSS DIFFERENT TYPES OF LCD PANELS DEMONSTRATE THE NEED FOR DISAGGREGATED ANALYSES OF ALLEGED CARTEL EFFECTS

51. In Section II, I explain that there are three broad categories of TFT-LCD panels with distinct histories, characteristics, and manufacturers, as well as a wide variety of panel types within each of the categories. Those distinctions point to the need for separate analyses of whether there was any effect of alleged cartel activities within each of these categories, and possibly within narrower product groupings within each category (*e.g.*, TFT-LCD panels for monitors separate from TFT-LCD panels for notebooks). Given that a study of cartel effects is a study of prices (actual prices and inferences about prices "but-for" the alleged cartel), the need to analyze each category separately follows from the observation that the categories of panels exhibit distinct price patterns. That is the topic of this section.

52. The section proceeds as follows. First, I show that the three main categories of TFT-LCD panels (TV panels, monitor/notebook panels and small panels for mobile devices) also exhibit distinct price patterns. Together with the distinct characteristics of these panels described above, and the different evidence for alleged cartel activities described in Section IV, below, this implies that separate analyses would be required to determine if there were any cartel effects in these categories. Such separate analyses are required not just because any effects from the alleged cartel may differ by category, but also because the distinct price patterns indicate that the effect of economic variables on prices may differ by category. Hence, including multiple categories in one regression analysis and assuming common effects of the economic variables on prices could yield a mis-specified model.

53. Second, I show that, even within each category, there are distinct price patterns by type of panel, including for different types of panels sold by the same firm. Again, this

points to the need for disaggregated analyses, treating different types of panels as separate observations in econometric analyses—and including controls (including econometric "fixed effects," as well as controls for panel-specific cost and the evolution of each panels through its lifecycle) for differences in the prices of different types of panels—rather than rolling panels into an aggregated index or failing to include sufficiently rich controls for differences in prices across panels. Analyses on aggregated indices run a significant risk of confounding changes in panel prices over time with the effect of a changing mix of panels.

A. PRICES FOR THE DIFFERENT CATEGORIES OF TFT-LCD PANELS FOLLOW DISTINCTLY DIFFERENT PATTERNS FROM ONE ANOTHER

1. Price patterns for small/mobile, monitor/notebook, and television panels are clearly distinct

54. Examination of the price patterns for the four largest TFT-LCD applications—monitor, notebook, mobile phone, and television—support the use of three broad categories for TFT-LCD panels (television, monitor/notebook, and small/mobile phone), as discussed above. In particular, Figure III-1 shows the de-trended average price (with average prices expressed relative to the average in January 2002) for small panels, monitor panels, notebook panels and TV panels for the 2002-2010 time period.[38] The data indicate that monitor and notebook panel prices track each other closely, while small panel and TV panel prices deviate from each other and from monitors and notebooks.[39] Table III-1 shows the correlation coefficients between these de-trended prices. The data show high correlation between the de-trended notebook and monitor panel prices, with a correlation coefficient of 0.92. The correlations between TV panel prices and notebook/ monitor panel prices, and between mobile panel prices and notebook/monitor panel prices are relatively low, ranging between 0.13 and 0.29. Finally, the correlation between TV

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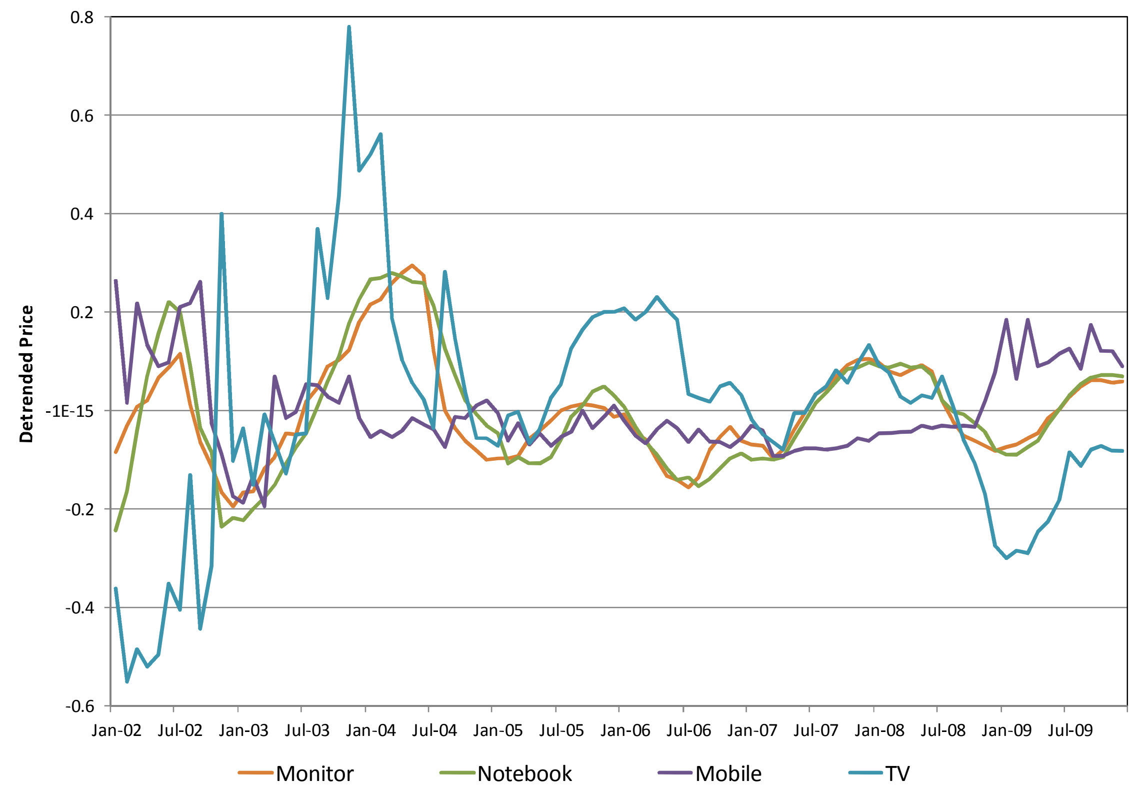
38 To be precise, the average prices are simply monthly quantity weighted average prices for each application, expressed relative to the average price in January 2002, then de-trended by taking residuals from a linear regression on a time trend. Changes in this measure reflect both changes in prices *and* changes in product mix in order to see if either type of change varies by product category.

39 Despite this high correlation, TFT-LCD panels for monitors and notebooks are different products and my econometric analysis later in the report finds that distinguishing them is useful.

panel prices and small panel prices is -0.47. Taken together, the correlations between these price series indicate similarity in pricing patterns for TFT-LCD panels used for monitors and notebooks. However, de-trended prices between the three broad categories (small/mobile, monitor/notebook, TV) are effectively uncorrelated.

Figure III-1: De-trended Average Prices by Application



Source: Defendants' transaction data.

Table III-1: Correlation of De-trended Price Series by Application

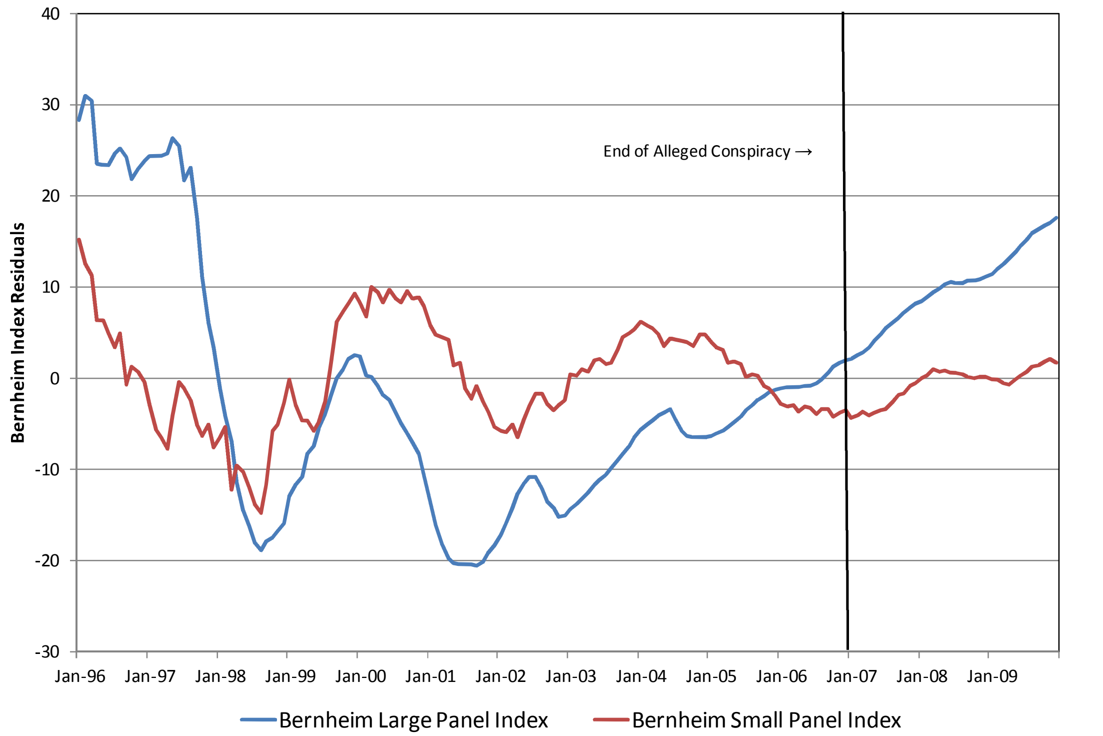
	Notebook	Mobile	TV
Monitor	0.92	0.13	0.29
Notebook		0.16	0.29
Small			-0.47

2. Analysis by Plaintiff Expert Dr. Bernheim support distinct price patterns for different types of panels

55. Analysis presented by Plaintiff Expert Dr. Bernheim also supports the need to analyze different types of panels separately. In particular, Dr. Bernheim's overcharge

analysis centers around two price indices, one index for TFT-LCD panels ten inches (in diagonal measure) and larger and one index for panels under 10 inches.[40] Dr. Bernheim indicates that he uses two separate indices to "estimate separate models for large and small panels rather than a single model because the characteristic price patterns for these two groups of products are identifiably different."[41] To see this clearly, Figure III-2 plots de-trended versions of Dr. Bernheim's small and large panel indexes. As seen in the Figure, these de-trended indexes show little relationship to each other, with a correlation of only 0.19.

Figure III-2: De-trended Bernheim LCD Panel Price Indices



Source: Bernheim Figure 7.

B. EVEN WITHIN CATEGORIES, PRICES FOR THE DIFFERENT TFT-LCD PRODUCTS DO NOT MAINTAIN A STABLE RELATIONSHIP OVER TIME

56. Although the categorization of TFT-LCD panels into three broad categories is quite useful, one should not mistakenly assume homogeneity of pricing patterns within each category. To the contrary, there is substantial evidence that prices of panels within

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40 *Bernheim Report,* ¶82.

41 *Bernheim Report,* ¶82.

each category—indeed even prices of panels within a category sold by the same firm—do not maintain a stable relationship over time.[42] One implication of this is that econometric analyses of TFT-LCD panel prices should analyze relatively disaggregated panel types using sufficient panel-specific controls to avoid confounding changes in the price of a given panel over time with a changing mix of panels, as can easily occur when analyzing broader price indices, for example.

1. Even within a common application, prices of different panels do not maintain a stable ranking over time

57. Dr. Connor advances the theory of a "price ladder" through which the prices for index or "modal" panels discussed at the Crystal Meetings were propagated to the non-modal panels which were not discussed at the Crystal Meetings.[43] However he acknowledges that mobile panels and panels under 10 inches were not included in the ladder,[44] and that the ladder took no account of key product characteristics such as resolution,[45] contrast ratio, bright dots or viewing angle.[46] He concluded that the ladder was "sloppy" and only worked "sort of okay."[47] In this section, I show that the data on pricing patterns across products within a given application contradict Dr. Connor's "price ladder" theory.

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42 This evidence serves to counter directly the claims of Dell's Expert, Dr. Connor. Dr. Connor claims that stable gaps between different panel prices (price laddering) makes it easy for one manufacturer to determine what others charge for different products. He contends that although there are many product combinations, many panels are one step from other panels (*e.g.*, 15.4" XGA panels are 20 percent more expensive than 14" XGA panels). *Connor Report,* ¶90 ("A cartel that must agree on prices for each and every variation in design characteristics is much less likely to be formed or stable than one based on an agreement on a small number of prices. The TFT-LCD cartel maintained predictable price differences among slight variations in items. To simplify collective pricing decisions, LCD managers and salespersons would price newer or larger panel variants using a basic, standardized, large-selling model and add percentage premiums to the basic model's price. In internal correspondences, this method of pricing is sometimes called 'laddering' (HITDOJCIV00521873).")

43 *Connor Report,* ¶90-92.

44 *Connor Depo*., 154:7-12.

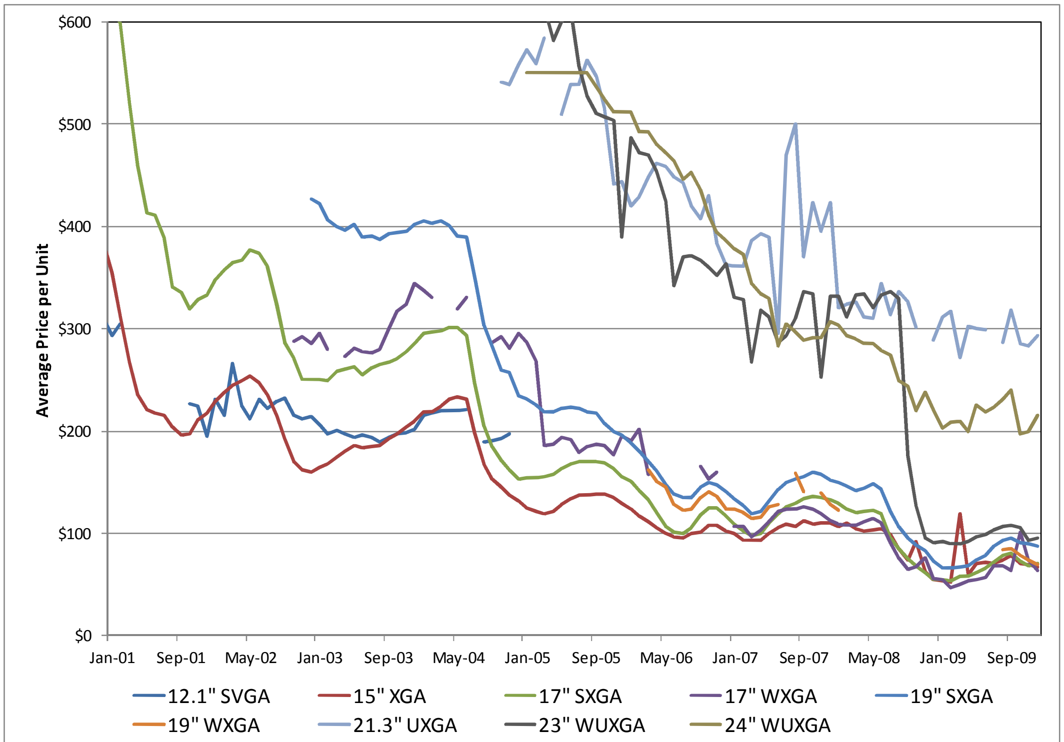
45 *Connor Depo*., 133:11-18.

46 *Connor Depo*., 148:6-149:15.

47 *Connor Depo*., 133:19-134:2 ("it worked in my view, sort of okay, not perfectly, but it was an okay, average cartel, not super duper, just average.")

58. Figure III-3 through Figure III-6 show that average prices of panels for a particular application, but with different sizes and resolutions, do not maintain a stable hierarchical relationship and instead cross each other over time.[48] The lack of a stable relationship is clear for all types of panels, but particularly so for TV panels and even more so for mobile phone panels, where the high degree of customization and differentiation makes any stable relationship impossible.

Figure III-3: Average Price for Selected Panels, Monitors, 2001-2009



Source: Defendants' transaction data.

[48] The figures occasionally show gaps in the price lines because I included panels in a month only when they had a minimum amount of sales in that month.

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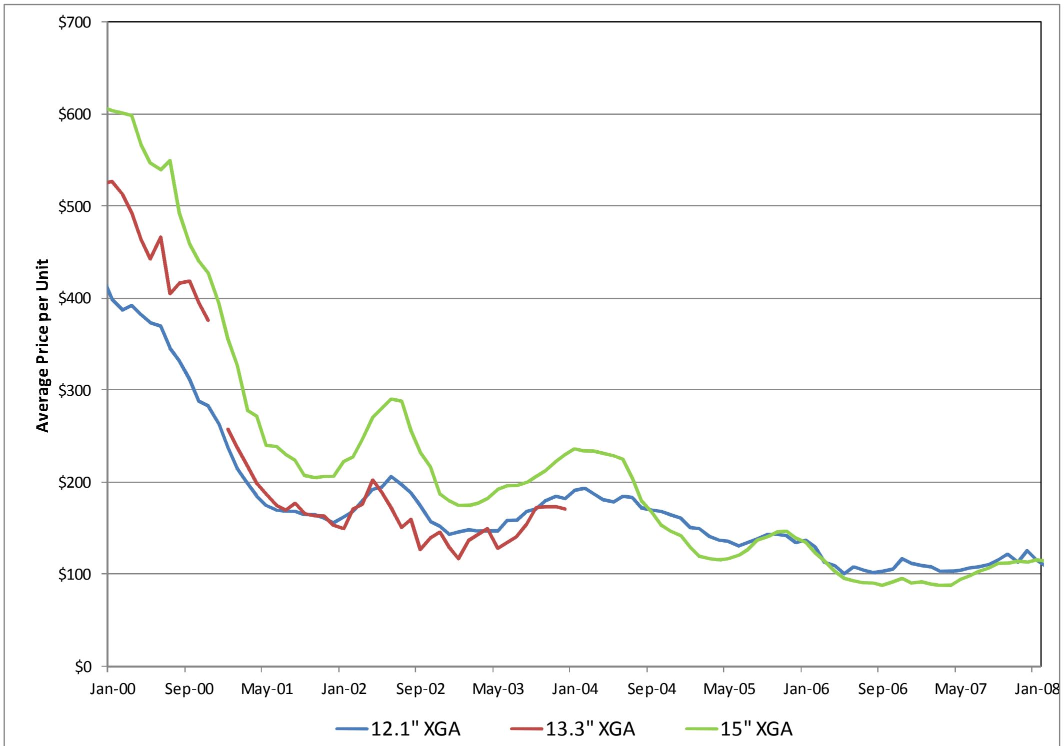
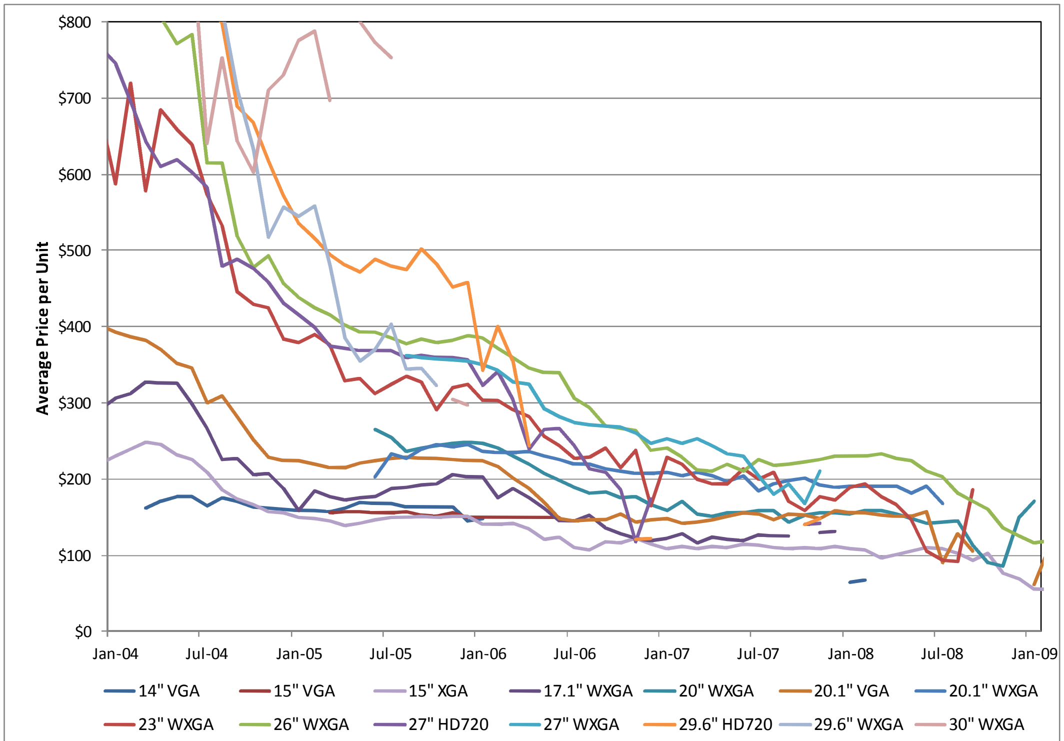
Figure III-4: Average Price for Selected Panels, Notebooks, 2000-2008



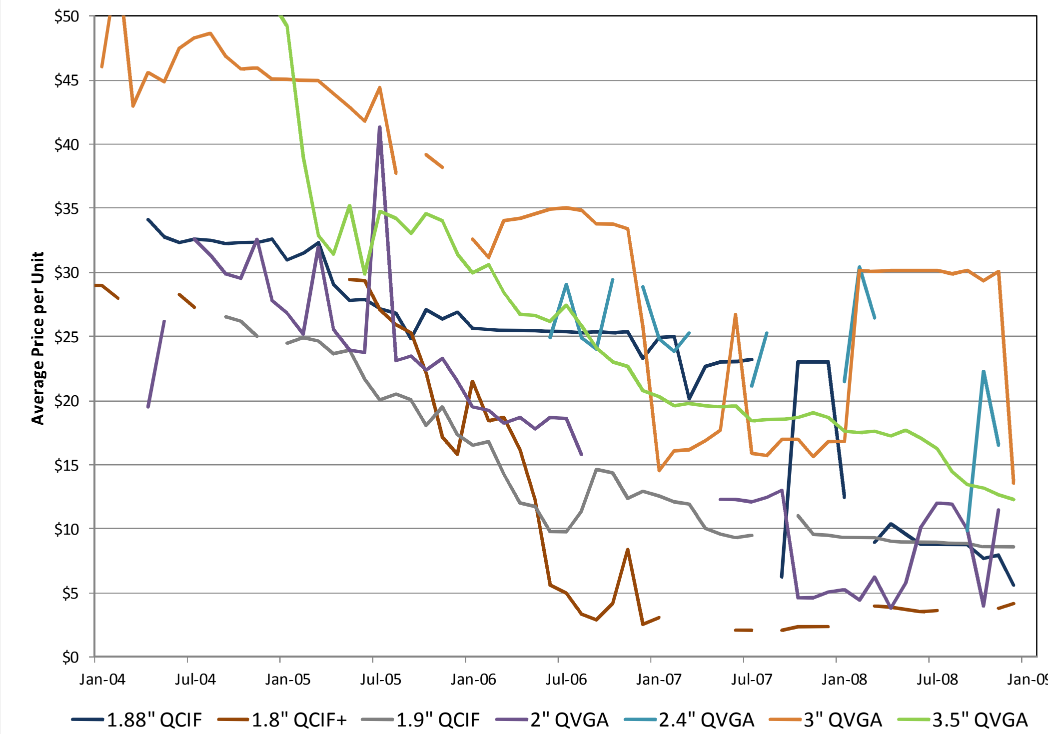
Source: Defendants' transaction data.

Figure III-5: Average Price for Selected Panels, TVs, 2004-2009



Source: Defendants' transaction data.

Figure III-6: Average Price for Selected Panels, Small (Mobile) Applications, 2004-2009



Source: Defendants' transaction data.

2. Even for a common application and supplier, prices of different panels do not maintain a stable relationship over time

59. Even if one focuses on prices for panels for a given application sold by a given buyer, the lack of any stable ordering of prices is readily apparent. Figure III-7 through Figure III-10 show that average prices of panels of a particular application, sold by a given manufacturer (but with different sizes and resolutions) do not maintain a stable hierarchical relationship, but instead often cross. Again, the absence of stable relationships is particularly obvious for the largest and smallest types of panels, for TVs and mobile phones.

Figure III-7: Average Price for Selected Panels, Monitors, AUO Only, 2004-2007

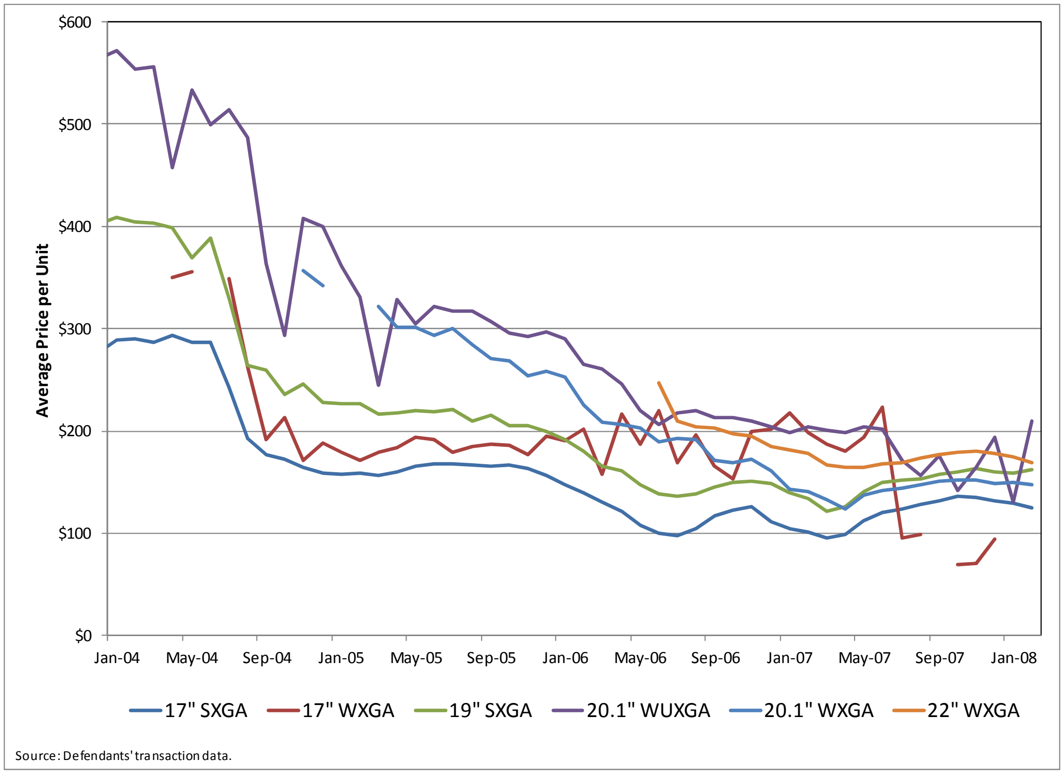


Figure III-8: Average Price for Selected Panels, Notebooks, Samsung Only, 2002-2008

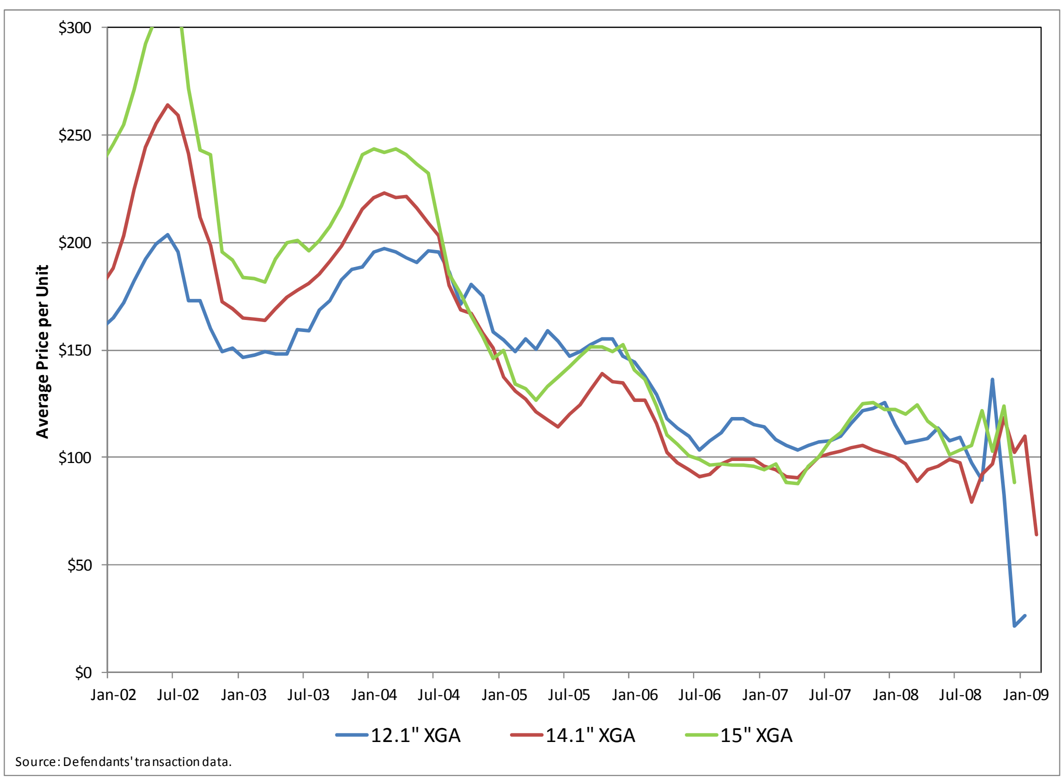


Figure III-9: Average Price for Selected, Panels, TVs, CMO Only, 2005-2007

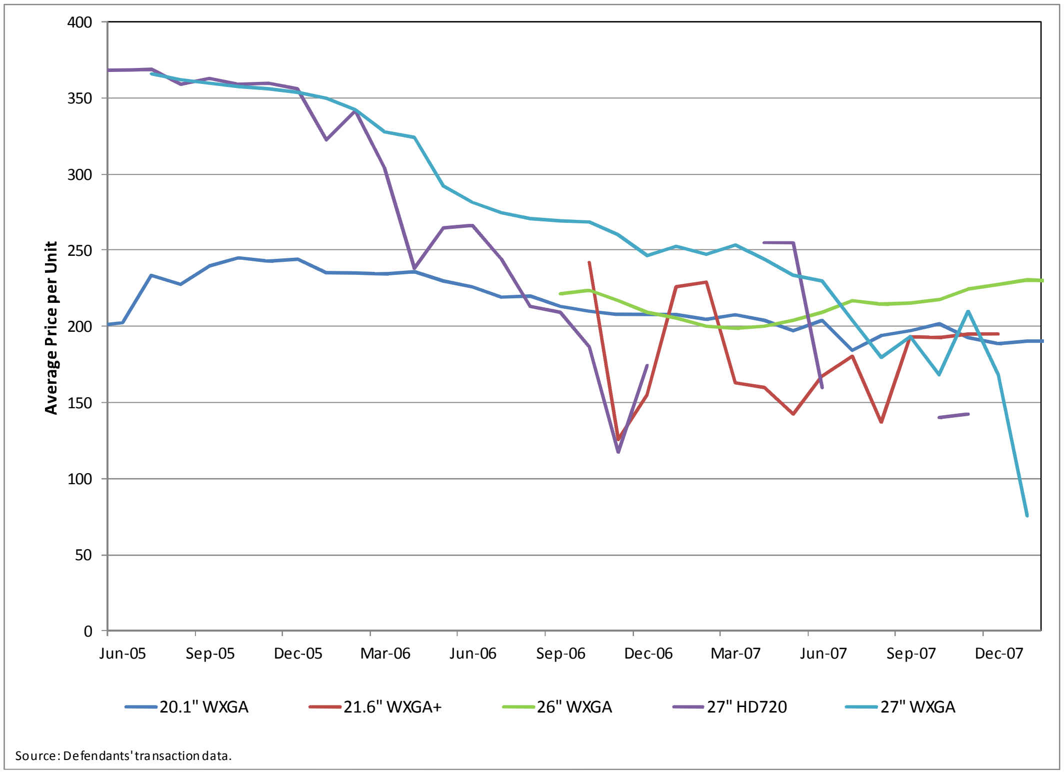
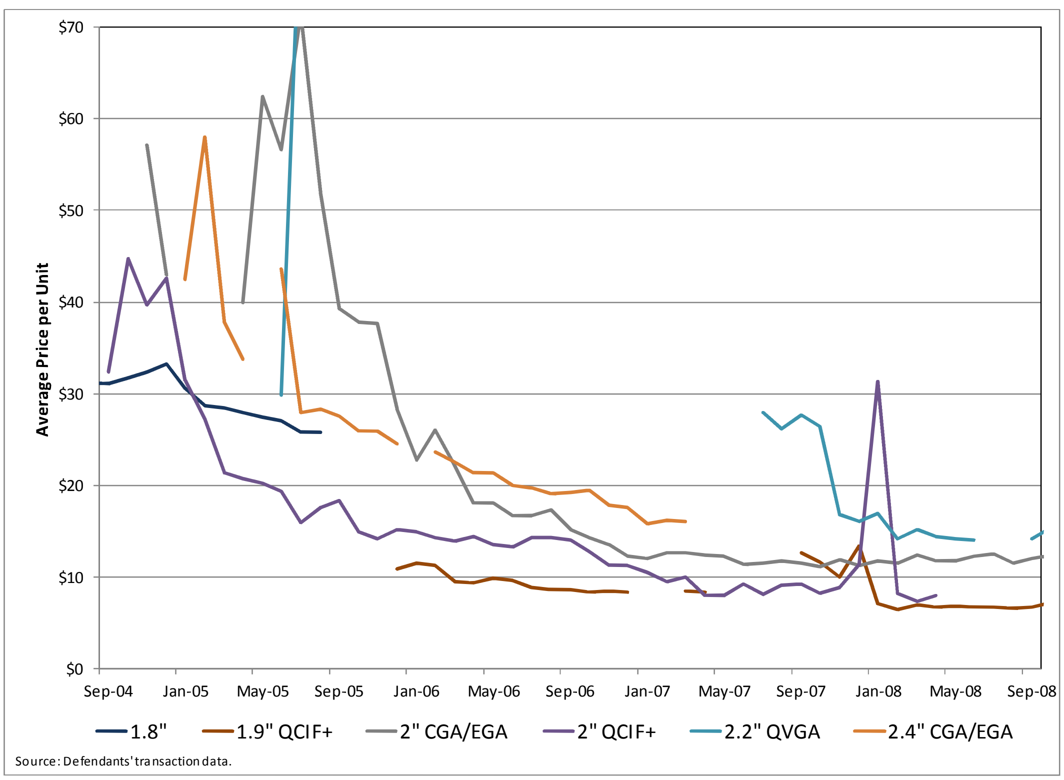


Figure III-10: Average Price for Selected Panels, Small (Mobile) Applications, Hitachi Displays Only, 2004-2008



IV. THE DOCUMENTARY RECORD OF COMMUNICATIONS BETWEEN DEFENDANTS CANNOT ESTABLISH THE EXISTENCE OF SIGNIFICANT OVERCHARGES

60. Plaintiff Experts rely on a large volume of documentary evidence in reaching their opinions regarding the existence of an alleged conspiracy.[49] It is not disputed that there is evidence of price discussions and other communications. It is clear that there are thousands of documents, running the gamut from discussion of future prices to simple discussions of industry conditions with no reference to pricing or production plans.

61. In this section, I make the following points with regard to what I can conclude from the documentary record in this matter:

- First, at most, the documentary record regarding price communications may indicate that Defendants tried to raise prices, but it cannot establish that those attempts were successful.[50] A demonstration of success in elevating prices requires an economic analysis—based on economic theory; the details of the TFT-LCD industry; and empirical data on prices, costs and other economic factors—of the difference between actual prices and the prices that would have held but-for the alleged conspiracy.
- Second, for those categories of panels for which there is a detailed record of discussions at Crystal Meetings, the documents indicate that not all Defendants participated, not all panels (*e.g.,* size and display combinations) were discussed, and, and panels that were discussed, were not discussed in all months in which they were sold.

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49 There are three general categories of such evidence: (1) guilty plea entered by Defendants in various cases related to the alleged cartel; (2) evidence related to the Crystal Meetings, including minutes of the meetings, which indicate participants, products discussed, and whether pricing was discussed; and (3) other documents, including emails and fact deposition testimony that bear directly or indirectly on bilateral communication. I recognize that this evidence is not necessarily the totality of potential evidence of communication between the competitors.

50 As an economist, I offer no opinion on whether any particular document does or does not constitute evidence of a price fixing agreement under U.S. law.

- Third, even when prices for a given panel/month combination were discussed at Crystal Meetings, evidence indicates that prices did not conform closely to the discussed prices. As I explain below in Section V, economics teaches that the internal constraint that often undermines a cartel agreement (assuming one exists) is the incentive and ability of cartel members to cheat on the agreement. The evidence of lack of adherence to the prices discussed at Crystal Meetings is consistent with either the lack of agreement on any single price or widespread cheating on the agreement.

A. DOCUMENTS DESCRIBING COMMUNICATIONS BETWEEN DEFENDANTS CANNOT PROVE SUCCESS IN GENERATING SIGNIFICANT OVERCHARGES

62. The focus of my economic analysis of overcharges is not to determine whether Defendants met, whether they discussed prices or even whether they tried to inflate prices. Instead, the focus is whether and to what extent the Defendants succeeded in raising prices above the levels that would have prevailed but-for the alleged cartel activities. As a matter of economics the two issues—communicating to try to inflate prices and succeeding in actually raising prices—are distinct. As detailed at length in Section V, below, there is a well-established economic literature indicating that attempts by cartels to raise prices may be significantly hindered by certain industry conditions and there is substantial reason to believe that many of those conditions apply in the TFT-LCD industry.

1. Documents describing general communications on marketplace conditions, or even attempts to raise price, cannot establish that there were significant overcharges

63. My review and my staff's review of the documents cited or produced by Plaintiff Experts reveal many documents in which there is general communication between some set of Defendants about marketplace conditions, in some cases including price.[51] Such documents establish that there were communications and that, in some cases, those communications may have involved attempts to inflate prices. However, the question of

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51 These documents are listed in Exhibit 2 under Materials Cited or Produced by Plaintiff Experts. They include documents cited or produced in *Netz Report*, *Netz Reply Report*, *Flamm Report*, *Flamm Reply Report*, *Jenkins Report*, *Rao Report*, *Connor Report*, *Bernheim Report*, and *Macartney Report*.

whether and to what extent prices were higher requires deeper economic analysis, including a study of relevant industry conditions and a determination of the difference between prices actually charged and those that would have prevailed but-for the communications on actual prices.

2. Discussions and actions in parties' individual self interest cannot prove cartel success in generating significant overcharges

64. Many documents reflect parties making statements that are economically self-evident, such as the fact that they would be better off if prices were higher or if total industry capacity were lower. Clearly such statements are true and, equally clearly, firms have a self interest in trying to convince other firms to raise their prices or reduce their capacity. Seeing documents reflecting such statements, then, should not be surprising and cannot establish that any parties actually raised prices above the but-for level (or reduced capacity) as a result.

3. The fact that meetings or communications took place for many years cannot prove cartel success in generating significant overcharge percentages

65. The mere fact that meetings and communications occurred, even if over a long period of time, cannot on its own prove that those communications must have raised price significantly. Hence, to the extent that Plaintiff Experts are contending that the existence of meetings and communications over a long period of time proves the existence of large overcharges, this argument fails on several dimensions:[52]

- First, the argument assumes one conclusion when the opposite is possible. As stressed above, a critical feature of the TFT-LCD industry is that prices were falling rapidly. There is no doubt that the firms in the industry would have liked to stop or reverse that trend. There is also no doubt (for reasons laid out in more

[52] Dr. Rao claims that there is no other explanation for individuals taking a risk to fix prices other than expectation of success. "It would have been irrational for the defendants to have engaged in such extensive communications and agreements for such an extended time period and at such a high personal risk unless they perceived that these communications and agreements were indeed successful in raising prices to their customers." (*Rao Report,* ¶75)

details in Section V below) that this would have been extremely difficult to accomplish in an industry with more than ten sellers, literally hundreds of products, steady introduction of new products, rapid technological development, capacity expansion, powerful buyers, and products differentiated on many dimensions beyond price. So the frequent meetings may equally have reflected the reality that panel prices continued to fall and panel makers continued to struggle for ways to stop or slow that process, perhaps unsuccessfully.

- Second, even a very small overcharge percentage corresponds to a large amount of revenue, so there is no way to use continued meetings to determine that the overcharge percentage must have been anywhere near as large as Plaintiff Experts claim. Table IV-1 provides an estimate of the worldwide volume of commerce during the 1998-2006 period, showing panel sales of over $159 Billion.[53] Based on these totals, even a one percent overcharge on these worldwide sales would have yielded well over $1 billion in incremental revenue.

Table IV-1: Potential Volume of Commerce Affected by Alleged Conspiracy

Hypothetical Overcharge %	Hypothetical Overcharge $
0.1%	159,270,000
0.5%	796,350,000
1.0%	1,592,700,000
2.0%	3,185,400,000
Total Volume of Commerce	159,270,000,000

Source: Flamm Report, May 25, 2011, Exhibit 27.

4. Documents that refer to cartel success are not dispositive and must be viewed in proper context

66. I acknowledge that a small subset of the documents cited or produced by Plaintiff Experts—particularly meeting minutes in the early portion (September 2001-July 2002) of the Crystal Meetings—contain references to pricing targets being met or other indications that attempts at price elevation were successful. Such documents are more informative than those that contain no reference to success and the time-periods and

[53] Looking only at sales to non-Defendants and unrelated entities, the total volume of commerce is still over $109 billion, making a 1 percent overcharge still greater than $1 billion.

products for which such documents exist are the most likely candidates for some actual overcharges from the alleged cartel. However, I make three points:

- First, to the extent that statements regarding successful price elevation are made when meeting with other Defendants, firms have an incentive to claim to have adhered to such price agreements, whether they did or not, in order not to precipitate a price war. For the same reason, the countervailing cases in which firms undercut any price targets may be underrepresented in Crystal Meeting minutes or other communications between firms.

- Second, such documents do not contain any indication of what the price would have been but-for the alleged cartel activities. Even in the absence of any cartel success, prices fluctuate from month to month (2006 in Figure II-20, above), and hence there will likely be some months in which competitive prices are relatively close to the prices that had been discussed previously by Defendants. As such, the mere fact that prices came close to targets in certain months does not prove the existence of large overcharges; *an empirical study of but-for prices is required to say anything about the magnitude of the overcharge.*

- Finally, and perhaps most importantly, documents referring to the success in raising prices for certain types of panels in certain time-periods speak *only* to those panels in those time-periods. As shown above, prices of different types of panels can and do move quite independently from one another. An attempt to sweep other types of panels or other time periods under the same rug with those for which there are documents pointing to cartel success is invalid. In particular, it is invalid to generalize from documents suggesting success in raising prices of, for example, notebook or monitor panels to say anything about success in raising prices of small panels.

B. EVIDENCE INDICATES THAT JAPANESE DEFENDANTS DID NOT ATTEND THE CRYSTAL MEETINGS

67. My review of the Crystal Meeting Minutes and depositions provides no evidence indicating that the Japanese Defendants initiated or attended the Crystal Meetings.[54, 55] In addition, the enforcement action brought by the U.S. Department of Justice (DOJ) in this matter does not allege participation by Japanese Defendants in any overall conspiracy relating to monitor and notebook panels.

68. In particular, five Taiwanese and Korean Defendants—AU Optronics, Chi Mei, Chunghwa, HannStar, and LGD—are identified by the DOJ as having participated in a common cartel agreement (notably beginning not in 1999 but rather in September 2001), and Samsung was accepted into the Antitrust Division's Corporate Leniency Program for its activities in the TFT-LCD industry.[56] But, with respect to those Japanese Defendants

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54 *See, e.g.,* Deposition of Brian Lee, Vol. III, July 28, 2010, 414:14-415:4 ("Q. BY MR. SORENSEN: As far as you know, the Japanese companies didn't have anything to do with starting crystal meetings, correct? A. Yes. Q. And did you ever hear that the Japanese companies had their own crystal meetings? A. Never heard."). *See also.*, Deposition of Makoto Chiba (TMD), 86:20-87:13 (testifying that he had no knowledge of the Crystal Meetings until they became public in 2006).

55 There is some deposition testimony indicating that Sharp attended the lower level vendor meetings, which I understand are not considered part of the Crystal Meetings, but rather a series of lower-level meetings that involved general discussions about the trends in the market and general volumes or prices rather than specific discussions about panel prices. (Deposition of Irine Chen, Vol. I, April 26, 2010, 46:10-48:13, Exhibit 1601). However, according to Dr. Connor, Sharp did not participate in the Crystal Meeting. *Connor Report,* n. 81 ("There is no record that Sharp participated in the Crystal Meetings, provided sensitive business information, or had a close technical or licensing relationship with any known participants in the global cartel.")

56 *See* the following "Information" filings by the Department of Justice in the United States District Court, Northern District of California, San Francisco Division: *United States of America v. Chungwa Picture Tubes, Ltd.*, November 12, 2008; *United States of America v. LG Display Company, Ltd. and LG Display America, Inc.*, November 12, 2008; *United States of America v. Chi Mei Optoelectronics*, December 8, 2009; *United States of America v. HannStar Display Corporation*, June 29, 2010. The participation of these Defendants is supposed to have ended at various points in 2006, ranging from January 31, 2006 through December 1, 2006.

Regarding AU Optronics, *see* the U.S. Department of Justice press release: "Largest Taiwanese LCD Producer, Houston-Based Subsidiary and Six Executives Indicted for Participating in LCD Price-Fixing Conspiracy," June 10, 2010.

Regarding Samsung, *see* Letter from Michael Scott (Antitrust Division of the Department of Justice) Re: Samsung Electronics Company Ltd., June 7, 2011, SAML-815331.

that have pleaded guilty, DOJ documents describe separate conspiracies, all of which are explicitly limited to certain products and customers, as opposed to an overall conspiracy with regard to monitor and notebook computers:

- Epson and Sharp pled guilty to participating in a conspiracy involving the sale of specific panels sold to Motorola for use in Razr mobile phones from Fall 2005 through the middle of 2006.[57]

- Sharp pled guilty to a conspiracy involving the sale of specific panels for Apple iPod music players from September 2005 to December 2006.[58]

- Hitachi Displays and Sharp each pled guilty to participating in a conspiracy to fix prices of certain panels sold to Dell. Hitachi Display's participation in a conspiracy to fix the prices of TFT-LCD panels sold to Dell for notebook computers is said to have spanned April 1, 2001 through March 31, 2004; whereas Sharp is said to have participated in a conspiracy with regard to TFT-LCD panels sold to Dell between April 2001 and December 2006.[59]

A fourth Japanese Defendant, Toshiba, has not pled guilty or been indicted for any illegal conduct, including attendance at the Crystal Meetings or bilateral communication. Thus, apart from the three customer- and product- specific agreements, the DOJ allegations and the guilty plea agreements involve no Japanese Defendants.

69. The transcript from the Proceedings to enter Hitachi Displays' guilty plea is also telling. David Ward, speaking for the United States government, indicated that "[t]he conspiracy to which LGD pled to and CPT pled to was a related, but separate, conspiracy

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57 *See* the following "Information" filings by the Department of Justice in the United States District Court, Northern District of California, San Francisco Division: *United States of America v. Epson Imaging Devices Corporation*, August 25, 2009; and U.S. Department of Justice press release, "LG, Sharp, Chungwa Agree to Plead Guilty, Pay Total of $585 Million in Fines for Participating in LCD Price-Fixing Conspiracies," November 12, 2008 (hereinafter, *DOJ Nov. 12 Press Release*).

58 *See*, *DOJ Nov. 12 Press Release*.

59 *See* the following "Information" filing by the Department of Justice in the United States District Court, Northern District of California, San Francisco Division: *United States of America v. Hitachi Displays Ltd.*, March 10, 2009; *DOJ Nov. 12 Press Release*.

that did not involve [Hitachi Displays]."[60] When directly asked by the Court whether the government was developing proof of "many separate little conspiracies," Mr. Ward replied:[61]

> Yes, Your Honor. We believe there was a larger conspiracy involving LG and CPT and others to fix the price of TFT-LCD sold to many manufacturers. The Government does not believe that either Hitachi or Sharp were involved in that conspiracy. We believe that Hitachi, Sharp, and other unnamed co-conspirators were involved in a separate conspiracy amongst themselves to fix the prices of TFT-LCD sold only to Dell.

C. For Monitor/Notebook Panels, a Substantial Percentage of Sales Was Not Covered by Crystal Meetings and Actual Prices Did Not Conform Closely to Discussed Prices

70. Of the three categories of panels, evidence of Defendant communications is most abundant for monitor and notebook panels. Nevertheless, the evidence on communications about monitor and notebook panels does not establish the existence of significant overcharges, particularly for all purchases of monitor and notebook panels from all Defendants in all portions of the alleged cartel period. In particular, in this section I show that (i) a fairly large percentage of sales of monitor and notebook panels were of panel types not discussed at recent meetings; and (ii) for those panels discussed at recent meetings, actual prices charged did not conform closely to discussed prices, calling into doubt what effect, if any, the discussions had on prices charged.

1. A large percentage of monitor and notebook panel sales during the damages period were of panels for which there was no corresponding price discussion.

71. Although the Crystal Meetings focused on monitor and notebook panels, it is certainly not the case that all sales during the damages period were made up of monitor and notebook panels for which there had been a corresponding price discussion. To the contrary, a substantial percentage of sales were comprised of panels for which there had been no price discussion corresponding to the month of the panel sale or any recent

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60 *United States of America v. Hitachi Displays Ltd.*, No. CR-09-0247 (N.D. Cal May 22, 2009), 15.

61 *United States of America v. Hitachi Displays Ltd.*, No. CR-09-0247 (N.D. Cal May 22, 2009), 16.

month. As a matter of economics, I would not expect there to be a significant effect of the alleged cartel on the prices of panels with no corresponding price discussion, which would also tend to reduce the overall overcharge percentage across all monitor and notebook panel sales.

72. As shown in Table IV-2, over the course of the Crystal Meetings, less than 50 percent of monitor and notebook panel sales consisted of application/size combinations for which there had been discussions regarding the price to charge in the month in which the panel was sold. Restricting this figure to months for which there were discussions of a panel's specific application/size/*display* combination would further reduce this number. Even including all sales of application/size combinations for which there had been a price discussion corresponding to one of the preceding *six months* yields only 67 percent of total monitor and notebook panel revenue during the damages period. Put differently, over the course of the Crystal Meetings, at least 30 percent of monitor and notebook panel sales consisted of panel types for which there had been no Crystal Meeting discussion regarding the price to charge for that panel for any of the preceding six months.

Table IV-2: Revenue of Monitor and Notebook Panels Around the Time of Crystal Meeting Price Discussions

		Revenue ($ millions)		
Application	**Size**	**Month of Discussed Price**	**Month of Discussed Price and the Two Months After**	**Month of Discussed Price and the Five Months After**
Monitor	15"	$6,939	$7,974	$8,762
Monitor	17"	$10,520	$13,485	$15,221
Monitor	17.1"	$11	$24	$44
Monitor	18"	$118	$135	$158
Monitor	18.1"	$200	$309	$481
Monitor	19"	$3,699	$5,300	$6,823
Monitor	20"	$9	$11	$18
Monitor	20.1"	$219	$429	$620
Monitor	21"	$14	$52	$80
Monitor	21.3"	$6	$8	$15
Monitor	22"	$0	$0	$0
Monitor	23"	$14	$35	$50
Monitor	24"	$15	$62	$156
Monitor	30"	$0	$0	$1
Discussed Monitors Total		***$21,766***	***$27,825***	***$32,429***
Notebook	12"	$10	$26	$40
Notebook	12.1"	$492	$737	$909
Notebook	13.3"	$127	$194	$207
Notebook	14"	$81	$214	$382
Notebook	14.1"	$3,764	$4,361	$4,880
Notebook	15"	$5,244	$6,358	$7,323
Notebook	15.2"	$83	$124	$175
Notebook	15.4"	$1,811	$2,584	$3,500
Notebook	17"	$6	$21	$48
Notebook	17.1"	$26	$34	$74
Discussed Notebooks Total		***$11,646***	***$14,653***	***$17,538***
Other Monitors	10.4"-30"	$21,769	$15,710	$11,106
Other Notebooks	10"-20.1"	$19,253	$16,246	$13,361
Non-Discussed Panels Total		***$41,022***	***$31,955***	***$24,467***
Grand Total		***$74,434***	***$74,434***	***$74,434***
Discussed Monitors Share		***50%***	***64%***	***74%***
Discussed Notebooks Share		***38%***	***47%***	***57%***
Discussed Panels Share		***45%***	***57%***	***67%***

Source: Defendants' transaction data; Plaintiff Experts' meeting prices and documents.

2. Even for those panels discussed at Crystal Meetings, prices actually charged were not tightly clustered around discussed prices

73. Although it is certainly true that, at some of the Crystal Meetings, prices for specific monitor and notebook panels for specific future months were discussed, some

Crystal Meeting attendees viewed the prices discussed as reference prices, with actual prices charged varying by customer.[62] Crystal Meeting participants acknowledged that they charged lower prices or believed that others charged lower prices than those discussed at the Crystal Meetings.[63]

74. Defendants' pricing data provide clear support for the conclusion that firms did not consistently adhere to prices discussed at Crystal Meetings. Regardless of the fact that prices were discussed for certain panels of particular applications, sizes and displays, Defendants continued to sell those panels at a wide range of prices. There is simply no empirical evidence that the prices discussed at Crystal Meetings became a single, fixed price around which Defendants closely congregated, or an effective minimum price below which Defendants rarely went.[64]

75. Table IV-3 summarizes information on transaction prices and the prices discussed at Crystal Meetings for all monitor and notebook panels for which price was discussed during at least one Crystal Meeting.[65] The table shows that a very significant percentage of panel sales took place at prices below the prices discussed in Crystal Meetings. Since the same panel-month combination may have been discussed at more than one Crystal Meeting, and different Crystal Meeting participants may have disclosed different prices

62 A CMO attendee, for example, indicated that the reference prices discussed were not minimum prices and the company could charge lower prices. (Deposition of Wen-Hung Huang, Vol. I, September 7, 2010, 85:19-25.)

63 Despite attending Crystal Meetings where prices were targeted, the CMO President testified that the most important thing was to have his fabs fully utilized and he instructed sales people to get more orders, which meant lowering prices. (Deposition of Jau-Yang Ho, Vol. 1, June 16, 2010, at 40:22-41:16 and 53:11-14.)

64 I note that, several Crystal Meeting discussions did not convey information on the display standard or the resolution of the panels discussed. For example, several Crystal Meetings refer to "Wide" panels of a certain size, with multiple display standards that match the "Wide" aspect ratio. Also, as shown in Table IV-3and Figure IV-1, several Crystal Meetings refer to panels of certain size, with no reference to the display standard. Even if a single price was discussed at the Crystal Meetings, it is not clear in these instances what price each Defendant would charge for panels of different display standards.

65 For all figures and calculations, I removed outliers from the Defendants' transaction data. For each year and panel application, I removed the transactions at the top and bottom one percent of the price distribution. This eliminated approximately 1.0 percent of monitor panel revenue, 0.6 percent of notebook panel revenue, 1.0 percent of TV panel revenue, 1.3 percent of mobile phone panel revenue, and 3.7 percent of revenue for other panel applications.

for the same panel-month combination, I calculate the share of sales below each of the following two cutoffs:

- the mid-point of the highest and lowest prices discussed for a specific panel-month combination.[66]
- the lowest price discussed for a specific panel-month combination.[67]

On average, approximately 62 percent of monitor and notebook panel sales were at prices below the midpoint of prices communicated in Crystal Meetings, and approximately 40 percent were at prices below the lowest price communicated by any participant. Table IV-3 also shows that, for many monitor and notebook panels, the majority of sales took place at prices below the lowest price discussed at the Crystal Meetings.

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66 In other words, to obtain the mid-point of discussed prices, I use the average of the highest and lowest price discussed for each panel-month combination. When Crystal Meeting minutes do not specify a general price for all participants and instead specify prices for specific participants, the highest and lowest prices I use correspond to the highest and lowest prices discussed for any participant.

67 Using the lowest price discussed would tend to find less cheating.

Table IV-3: Share of Industry Revenue at Transaction Prices below Midpoint or Lowest Price Communicated at Crystal Meetings, by Panel

Panel	Revenue Below Midpoint Communicated Price	Revenue Below Lowest Communicated Price
MT 17" SXGA	57.7%	34.7%
MT 15" XGA	63.9%	39.4%
MT 19" SXGA	64.3%	47.3%
NB 14.1" XGA	66.6%	48.3%
NB 15.0" XGA	63.3%	41.8%
NB 15.4" WIDE	52.4%	34.2%
MT 20.1" WIDE	15.4%	8.6%
NB 12.1" XGA	77.0%	64.6%
MT 18.1" SXGA	80.2%	79.8%
NB 15" SXGA+	58.1%	32.0%
NB 13.3" XGA	38.0%	35.8%
NB 14.1" SXGA+	60.4%	60.4%
NB 12.1" SVGA	70.4%	70.4%
NB 17" WIDE	84.8%	84.7%
MT 24" WIDE	77.7%	77.7%
NB 14" WIDE	97.0%	97.0%
NB 15.2" WIDE	8.2%	8.2%
MT 19" WIDE	95.4%	0.2%
MT 23" WIDE	99.8%	83.6%
NB 15" SXGA	92.6%	92.5%
NB 15" UXGA	53.2%	28.2%
MT 21.3" UXGA	0.5%	0.5%
NB 14" XGA	100.0%	100.0%
MT 18" SXGA	67.7%	53.3%
MT 21" WIDE	74.0%	74.0%
MT 17" WIDE	52.0%	39.2%
Average for Panels with Display Information	**61.5%**	**39.7%**
MT 17"	66.7%	52.6%
MT 15"	65.6%	58.7%
MT 19"	49.1%	31.2%
NB 14.1"	43.5%	27.0%
NB 15"	54.6%	41.9%
NB 15.4"	62.8%	46.0%
NB 12.1"	83.3%	74.0%
NB 13.3"	57.3%	54.0%
MT 18.1"	43.9%	41.7%
NB 17.1"	81.1%	81.1%
NB 14"	32.5%	22.9%
NB 17"	3.0%	1.2%
NB 15.2"	48.4%	48.4%
MT 17.1"	94.5%	94.5%
MT 18"	53.1%	46.1%
NB 12"	69.3%	65.6%
MT 20"	0.0%	0.0%
Average for Panels Without Display Information	**59.5%**	**46.4%**

Sources: Defendants' transaction data; Plaintiff Experts' meeting prices and documents.

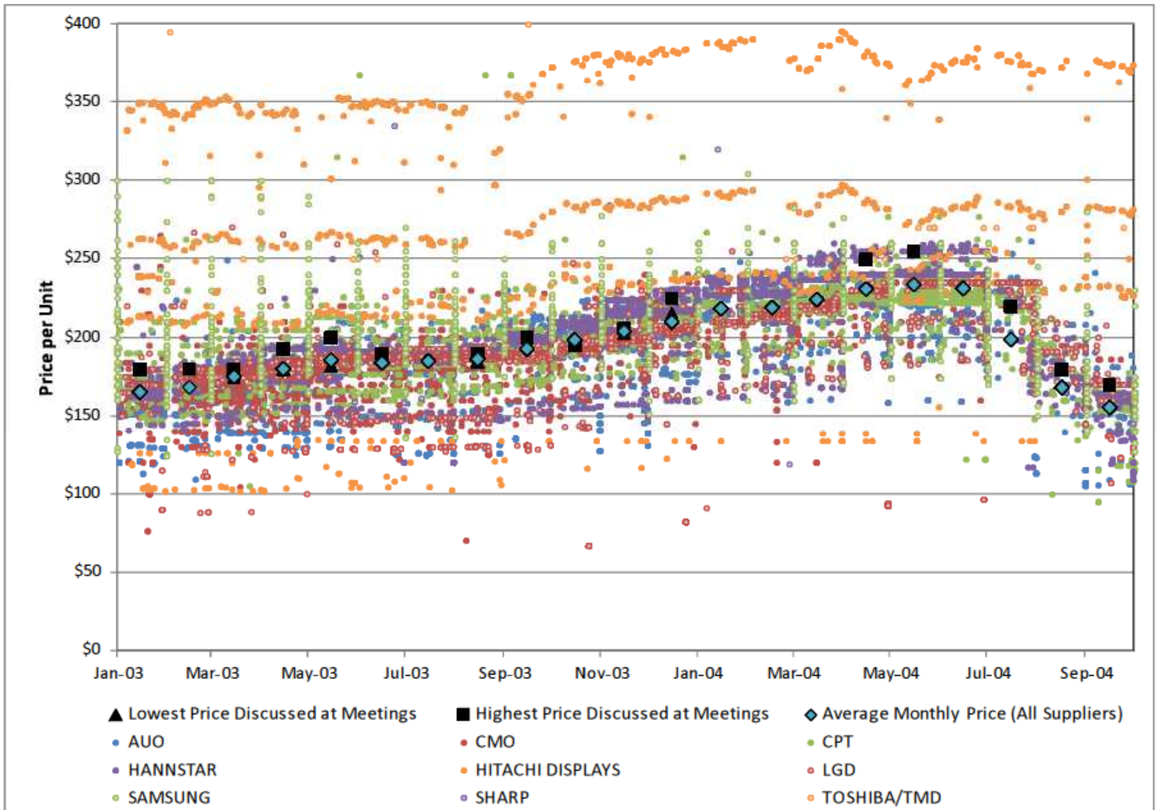
76. As additional empirical evidence, the following figures compare the prices discussed at the Crystal Meetings with actual transaction prices for various monitor and notebook panels. The figures include the highest and lowest price discussed for a given panel in a given month at the Crystal Meetings, the full set of actual transaction prices from each Defendant, and the average monthly price from all Defendants' transactions. The wide dispersion in transaction prices displayed in the figures indicates that Crystal Meeting participants did not stick closely to the discussed prices. Indeed, as seen in the figures, a large number of transactions were below the lowest price discussed, and in many instances the average price charged by all Defendants was below the lowest price discussed at the Crystal Meetings. This is further evidence that the attempts to fix price fail to eliminate cheating or that no agreement was ever reached in the first place.[68]

77. Figure IV-1 compares discussed prices to prices actually charged for the high selling 15" Monitor panel.[69] Transaction prices show an enormous range around the prices discussed in Crystal Meetings.

68 Evidence of cheating does not mean that there was not an overcharge, but it is a symptom of cartel breakdown and therefore one should not be surprised to find little or no effect from the alleged cartel.

69 The Crystal Meeting minutes often refer specifically to 15" XGA when display standard (XGA) is discussed. In other instances, the minutes only refer to 15" monitors, so the display standard is not known. The analysis in Figure IV-1 covers all discussions of 15" monitor panels in which display information was not discussed, and includes transaction prices for all 15" monitor panels, regardless of display standard. Figure IV-7 shows Crystal Meeting prices and transaction prices specific to the 15" XGA monitor panel.

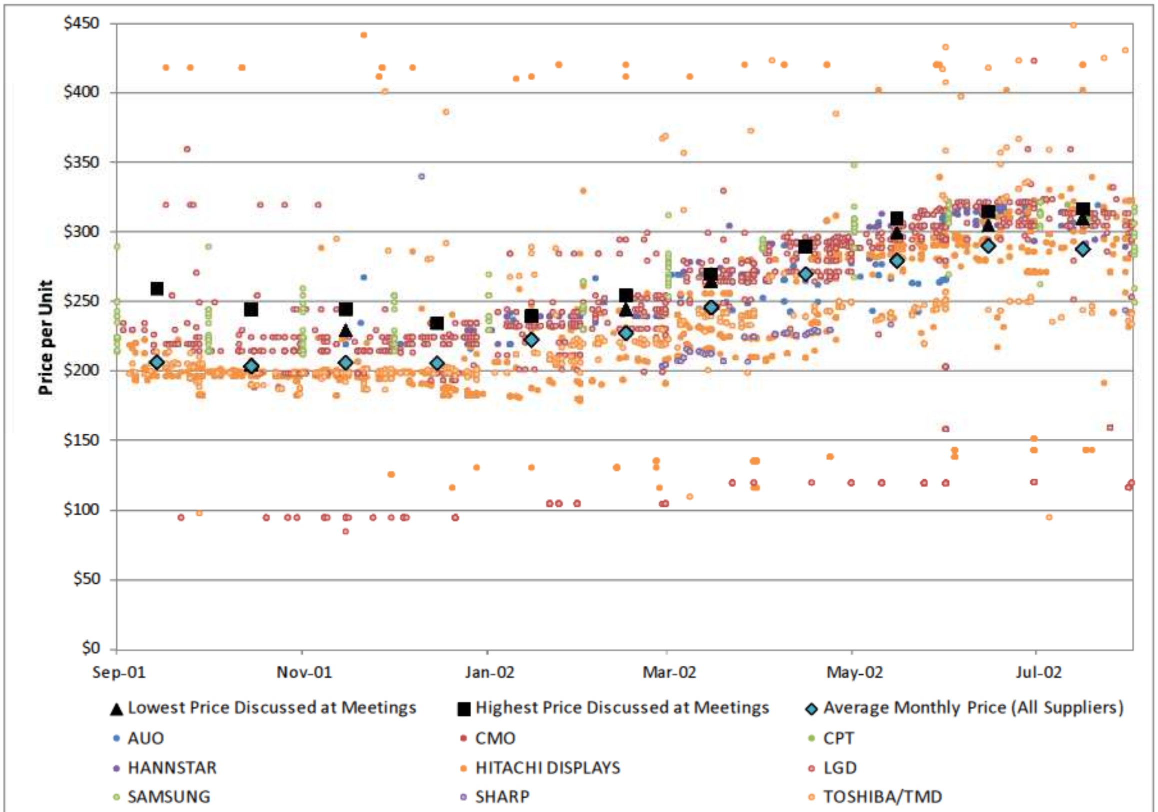
Figure IV-1: Prices Communicated at Crystal Meetings and Actual Transaction Prices, 15" Monitor (No Display Information Discussed)



Sources: Defendants' transaction data; Plaintiffs experts' meeting prices and documents.

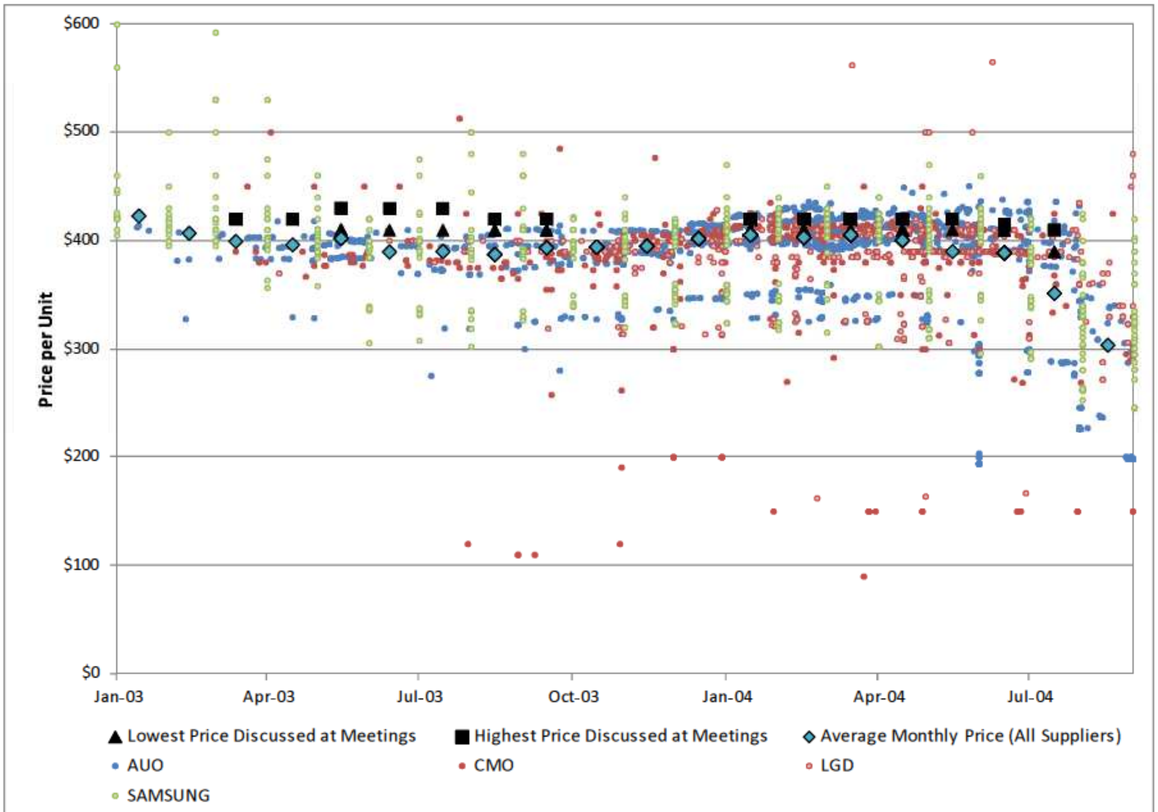
78. Figure IV-2 and Figure IV-3 show transaction prices for two specific high-selling application/size/resolution combinations, the 15" XGA notebook panel and the 19" SXGA monitor panel. Unlike the 15" monitor panel price shown in Figure IV-1, the price discussions, reflected in Figure IV-2 and Figure IV-3, referred to both size and display standard. Even with this additional panel specificity, there remains significant dispersion in transaction prices across Defendants and across different transactions of the same Defendant. Notably, average transaction prices were below the prices discussed at the Crystal Meetings for long periods of time.

Figure IV-2: Prices Communicated at Crystal Meetings and Actual Transaction Prices, 15" Notebook (XGA)



Sources: Defendants' transaction data; Plaintiffs experts' meeting prices and documents.

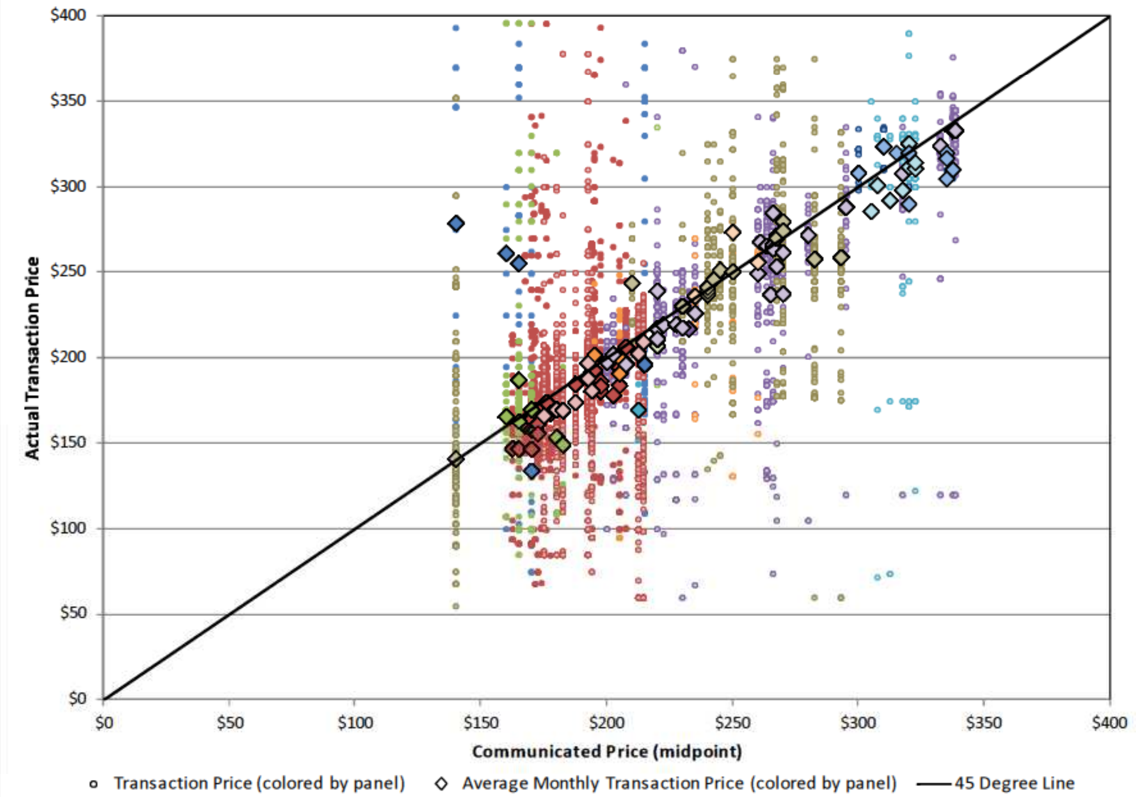
Figure IV-3: Prices Communicated at Crystal Meetings and Actual Transaction Prices, 19" Monitor (SXGA)



Sources: Defendants' transaction data; Plaintiffs experts' meeting prices and documents.

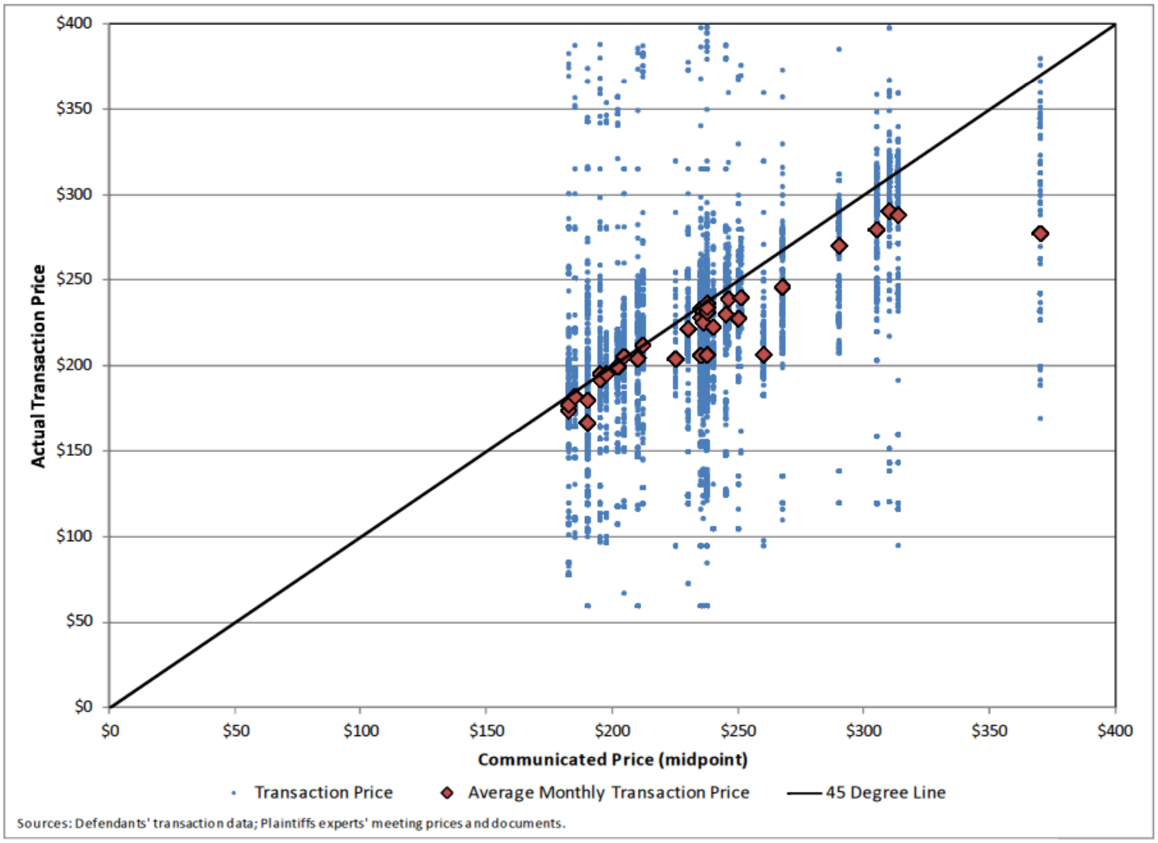
79. As additional evidence, Figure IV-4 and Figure IV-5 provide a summary of discussed vs. actual prices for notebook panels. Along the 45-degree line in these figures, communicated prices are equal to actual transaction prices for different panels. Figure IV-4 shows actual and discussed prices for all Notebook panels (where different panels are shown in different colors), excluding the 15" XGA Notebook panel, which is shown in Figure IV-5. The large dispersion in transaction prices around—and frequently far below—the prices discussed in Crystal Meetings is plainly evident.

Figure IV-4: Prices Communicated at Crystal Meetings and Actual Transaction Prices, All Notebook Panels, Excluding 15" XGA



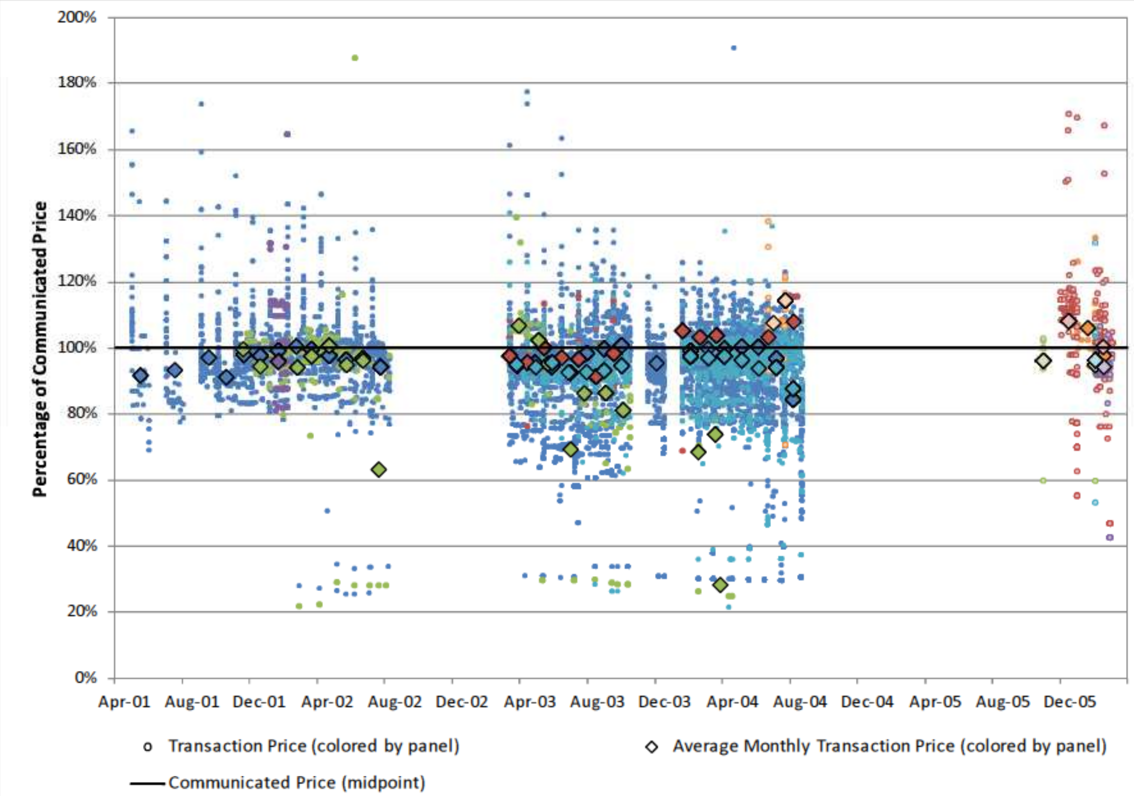
Sources: Defendants' transaction data; Plaintiffs experts' meeting prices and documents.

Figure IV-5: Prices Communicated at Crystal Meetings and Actual Transaction Prices, 15" Notebook (XGA)



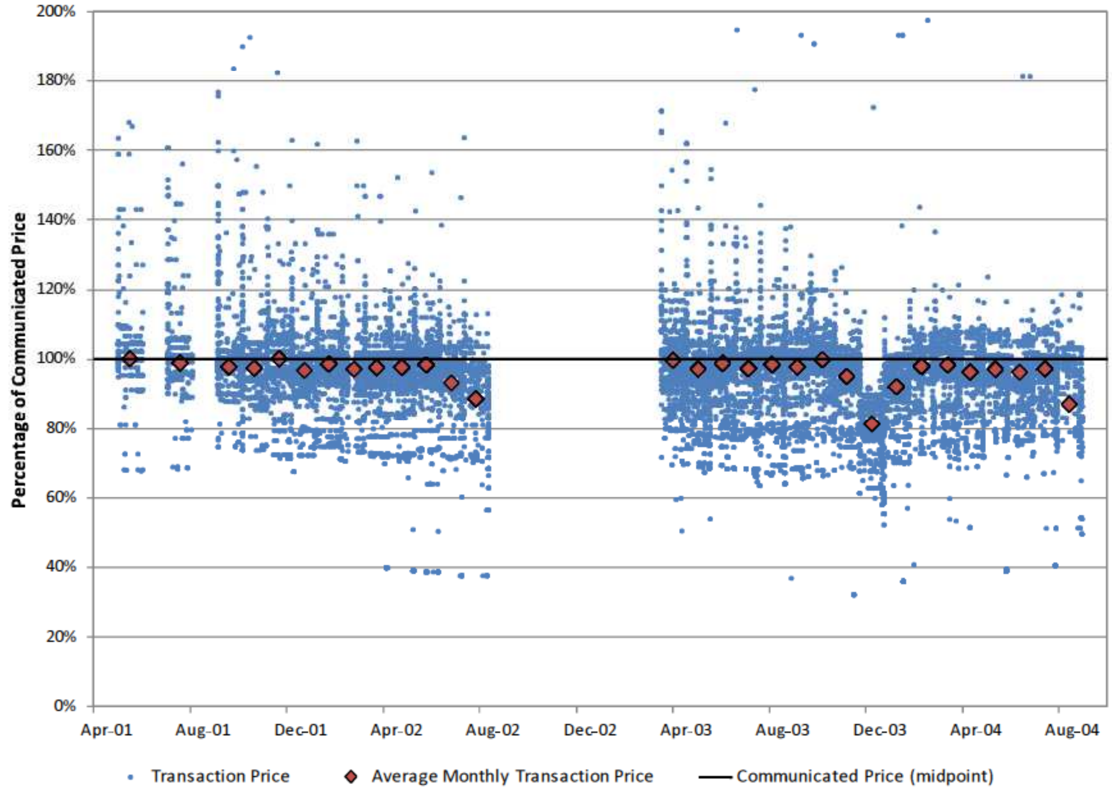
80. Finally, Figure IV-6 and Figure IV-7 summarize discussed vs. actual prices for monitor panels. These figures use a horizontal line to show the percentage difference between the actual transaction prices and the communicated price. Figure IV-6 shows the percentage differences for all Monitor panels (colored by panel), excluding the 15" XGA Monitor panel, which is shown in Figure IV-7. Again, regardless of the panel discussed, there is no evidence that Defendants congregated around the prices discussed at Crystal Meetings, or that the Crystal Meetings set an effective minimum price below which Defendants rarely went. Many transaction-specific prices and most average prices for a given panel fall well below those discussed at Crystal Meetings.

Figure IV-6: Prices Communicated at Crystal Meetings and Actual Transaction Prices, All Monitor Panels, excluding 15" XGA



Sources: Defendants' transaction data; Plaintiffs experts' meeting prices and documents.

Figure IV-7: Prices Communicated at Crystal Meetings and Actual Transaction Prices, 15" Monitor (XGA)



Sources: Defendants' transaction data; Plaintiffs experts' meeting prices and documents.

81. Given the evidence that firms were not consistently following the prices set at the Crystal Meetings, it is not clear how, if at all, the Crystal Meetings affected prices of monitor and notebook panels. If the alleged cartel exchanged information on prices but no targets were set, or if price targets were set but not followed, it should not be surprising to find that the cartel was unable to raise prices significantly.

82. The considerable evidence of pricing below the levels discussed in the Crystal Meetings raises obvious questions regarding whether the alleged cartel participants were able to detect this cheating at the time it occurred and whether they were able to react in such a way as to deter further low prices. In Section V, below, I discuss how cartel effectiveness is undermined by internal threats through cheating.

V. THE TFT-LCD INDUSTRY AND THE ALLEGED CARTEL EXHIBIT MANY CHARACTERISTICS THAT HINDER A CARTEL'S ABILITY TO RAISE PRICE SIGNIFICANTLY

83. In the previous sections of this report, I have set out the background of the TFT-LCD industry, and explained why the documentary record of meetings, however lengthy, does not substitute for actual economic analysis of whether there were significant overcharges. In this section, I go on to demonstrate that economic theory applied to the relevant facts about the TFT-LCD industry and alleged cartel also cannot establish that the alleged cartel significantly inflated prices. The TFT-LCD industry and the alleged cartel exhibit many characteristics that are known to hinder cartels' ability to raise price significantly.

84. Following this section, the remainder of this report explains that available empirical evidence shows at most small price effects from the alleged cartel activities. This result is not surprising in light of the characteristics of the TFT-LCD industry that I discuss in this Section.

85. I recognize that Dr. Connor and Dr. Rao apparently disagree with me and instead believe that the characteristics of the TFT-LCD industry make it prone to allowing a cartel to be successful. I include references to certain arguments on these topics made by Dr. Connor and Dr. Rao. However, the fact that there may be economic theories under which the alleged cartel could have succeeded, as well as theories that indicate it likely failed (presented below), proves only that the actual success or failure of the alleged cartel is an open question that needs to be resolved empirically, which is one of my main conclusions.

A. Economic Theory of Cartels

86. As described above, the record in this matter indicates that there were numerous communications among various subsets of the Defendants between 2001 and 2006. However, neither the fact of these meetings nor the admission of liability by some of the Defendants' executives automatically implies that prices were increased significantly. This is because an agreement among horizontal competitors to raise price may fail to raise price significantly above that which would have prevailed in the absence of the

agreement. Although companies may desire to form a cartel to raise industry profits, economic conditions in the industry and each firm's strong, individual incentive to maximize its own profits may prevent the firms from carrying out their joint plan. Indeed, a large body of economic literature establishes that attempts by cartels to raise prices may not be successful.[70]

87. The economic theory of cartels assumes that firms desire to maximize their profits.[71] If firms could agree jointly to reduce industry output and raise prices, then industry profits could increase over the level of profits that would otherwise exist. However, although a joint agreement to reduce output and raise price could increase industry profits, there are significant internal and external constraints to the successful implementation of such an agreement.

88. The external constraints come from firms not in the alleged cartel. These constraints arise if there are firms that do not participate in the cartel and that have the capacity to expand output significantly, or if there are new firms that can enter. Either of these possibilities threatens the cartel because the cartel's efforts to increase prices (and therefore drive profits up) will attract additional output—either from non-participants that increase production in response to the higher prices or from new firms that enter the industry. Hence, a cartel will likely be unsuccessful in sustaining lower output and a corresponding higher price when expansion of non-cartel members or entry can easily occur.[72, 73]

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70 For a survey of the literature, *see*, Margaret C. Levenstein and Valerie Y. Suslow (2006) at 45 "What Determines Cartel Success?" *Journal of Economic Literature*, 44(1). Levenstein and Suslow note, for example, that "[t]here are cases where cartels have continued to exist on paper for many years with little sustained effect on price."

71 For a discussion of the theory of cartels, *see* Dennis W. Carlton and Jeffrey M. Perloff (2005), *Modern Industrial Organization*, 4th edition at 122-154.

72 Blum (2007) examines the East German cement cartel over the period 1997-2002. He concludes that the cartel was not effective before 2001, and a price war erupted in 2002, due to increased imports. "Most likely, imports from Poland and Czech Republic were dumped into the East German market, and some medium-sized producers were responsible for the cartel never working." (Ulrich Blum (2007), "The East German Cement Cartel: Cartel Efficiency and Policy After Economic Transformation," *Eastern European Economics* 45:6 at 5.)

89. Economic theory also makes clear that, even in situations in which external constraints are limited, cartels are far from guaranteed to succeed as they may break down from within. Indeed, economists have argued that the internal constraints—the incentives for each member of the cartel to capitalize on the fact that other cartel members are setting higher prices and selling less output in order to capture more of the market through lower prices—are the primary reason why cartels often fail. As Stigler (1964) explained:[74]

> It is a well-established proposition that if any member of the agreement can secretly violate it, he will gain larger profits than by conforming to it… If price is above marginal cost, marginal revenue will be only slightly less than price (and hence above marginal cost) for price cuts by this one seller.

90. Put simply, the internal constraints arise because the incentives of individual cartel members conflict with the incentives of the group. Although firms are jointly better off if they all agree to raise price, *any individual firm, is better off if, having convinced other firms to raise their prices, it undercuts the agreed-upon price*. Generally, every firm that is a party to a cartel agreement has an individual incentive to undercut the agreed-upon price. This conflict between the incentives of individual firms and the incentives of the group acting together can make it difficult to maintain a cartel and is known to lead to cartel breakdown, as cartel members often cheat on agreements.

91. An effective punishment mechanism that reduces or eliminates the profits from cheating can enhance cartel effectiveness.[75] A common punishment mechanism is for

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73 Hillman (2010) discusses the international tin cartel created by a series of intergovernmental agreements beginning in the 1920s. The International Tin Committee (1927-1956) was given the power to control production. It was succeeded by the International Tin Council, which formed six agreements over the period 1956-86. Hillman attributes the eventual failure of the cartel to the stimulative effect of higher prices. "Diagnosis of the ultimate source of the failure of the Council has pointed in the direction of price policy. Prices were set too high, reducing consumption and stimulating outside production." (John Hillman (2010), *The International Tin Cartel*, Routledge at 367.)

74 George J. Stigler (1964), "A Theory of Oligopoly," *Journal of Political Economy* 72(44) at 46.

75 Carlton and Perloff (2005) at 142. Price wars may also result from a cartel simply breaking down, with many members defecting from the agreement. That is, price

other cartel participants to expand output and reduce price in response to perceived cheating on an agreement. When this occurs, however, prices can rapidly decline, falling to or even below competitive levels, creating periods of time when cartels do not inflate prices. The economic literature provides numerous case studies of cartels that punished cheaters by cutting prices or reverting to competition, (*e.g.*, the diamond cartel[76] and the lysine cartel).[77]

92. Despite the evidence presented in Section IV indicating widespread cheating on (or inability to adhere to) Crystal Meeting prices, Plaintiff Experts offer no meaningful evidence to establish that effective punishments were carried out. For example, Dr. Connor's only evidence of punishment is testimony that alleged cartel members "harangued" each other and used "shame" to punish cheating.[78] As a matter of economics, "haranguing" and "shaming" are not effective forms of punishment unless they are accompanied by an effective method of reducing the cheating firms' profits. Dr. Connor fails to analyze whether such methods existed.

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declines may represent attempts to discipline cheating or a breakdown of the cartel. In either case, the effect is the same: a temporary or permanent reduction in price.

76 In a study of the diamond cartel, Bergenstock, Deily, and Taylor (2006) stated that "cartel members have occasionally cheated, and De Beers has a reputation for aggressive action against anyone threatening the long-run stability of the diamond market." They gave two examples of such punishment. First, "in the early 1980s, De Beers is alleged to have punished Zaire for attempting to leave the cartel by flooding the market with the low-quality industrial diamonds that were Zaire's principal product." Second, "De Beer's greatly increased its sales of low-quality rough diamonds to Indian diamond cutters in 1996 when Argyle, an Australian company, left the cartel…" (Donna J. Bergenstock, Mary E. Deily, and Larry W. Taylor (2006), "A Cartel's Response to Cheating: An Empirical Investigation of the De Beers Diamond Empire," *Southern Economic Journal* 73(1) at 174.)

77 Yuliya Bolotova, John M. Connor, and Douglas J. Miller (2008), "The Impact of Collusion on Price Behavior: Empirical Results from Two Recent Cases," 26 *International Journal of Industrial Organization*.

78 Dr. Connor suggests that the alleged cartel in this case was unique in its reliance on threats and shaming as a response to cheating. *Connor Report*, ¶¶55, 132 ("Punishment of deviants from the price agreements seems to have taken a different form in the TFT-LCD cartel than in other historical cartels with which I am familiar. At some Crystal Meetings there are hints in the language of the minutes that *shaming* was used as a way of bolstering compliance with price agreements." (emphasis in original))

93. The extent to which the internal and external constraints on cartel stability hinder the ability of the cartel to raise price depends on the specifics of the industry in question. Hence, an analysis of the likelihood of success of the alleged cartel activities in the TFT-LCD industry must begin with an intensive, fact-based analysis of the characteristics of the industry and alleged cartel activities to see whether it is or is not likely to support a successful price-fixing cartel.

94. A careful evaluation of the TFT-LCD industry reveals that among its fundamental characteristics are precisely those that make cartel success unlikely.[79] This reinforces the theme made throughout the report thus far: The fact that at least some Defendants attempted to raise prices in some instances does not mean they succeeded. In fact, there are substantial reasons to believe they failed and clear empirical evidence should be required to prove otherwise.

95. Among the most relevant characteristics of the TFT-LCD industry are:

- the production technology has evolved rapidly;
- the industry is characterized by learning by doing;
- the products are heterogeneous and frequently customized;
- a substantial number of new TFT-LCD products were introduced during the alleged cartel period;
- the industry's is dynamic, including new entry and capacity expansion;
- the industry is unconcentrated by standard measures;
- many Defendants are vertically integrated;

79 Recent discussions of the factors that affect cartel success can be found in: Margaret C. Levenstein and Valerie Y. Suslow (2010), "Breaking Up Is Hard to Do: Determinants of Cartel Duration," *Journal of Law and Economics* (forthcoming); Dennis W. Carlton and Sam Peltzman (2010), "Introduction to Stigler's Theory of Oligopoly," *Competition Policy International*; Levenstein and Suslow (2006); Carlton and Perloff (2005), Chapter 5; Peter Z. Grossman, *ed.,* (2004), *How Cartels Endure and How They Fail*; Marc Ivaldi, Bruno Jullien, Patrick Rey, Paul Seabright, and Jean Tirole (2003), "The Economics of Tacit Collusion," IDEI; Alexis Jacquemin and Margaret E. Slade (1989), "Cartels, Collusion, and Horizontal Merger," in Richard Schmalensee and Robert Willig, *eds.*, *Handbook of Industrial Organization.*

- the buyers are heterogeneous; and
- many buyers having substantial power that may enable them to undo efforts by the alleged cartel members to raise prices and facilitate cheating among cartel members.

In the remainder of this section, I discuss each of these characteristics in turn.

B. Rapidly Evolving Production Technology

96. The economic theory of cartels supports the idea that industries experiencing rapid technological change will find it more difficult to maintain a price-fixing agreement. For example, Jacquemin and Slade (1989) note:[80]

> Industries that are subject to rapid technical change find it particularly difficult to reach agreements. Technical change can introduce differences in product lines, production cost, and demand conditions. In addition, the pace and direction of innovation is difficult to predict.

And, as stated in a report to the European Competition Commission:[81]

> Innovation makes collusion on prices less easy to sustain. The reason is that innovation, particularly drastic ones, may allow one firm to gain a significant advantage over its rivals. This prospect reduces both the value of future collusion and the amount of harm that rivals will be able to inflict if the need arises… Therefore, in both instances the same conclusion holds: *The more likely innovation is, the more difficult it is to sustain collusion.* Collusion is thus less of a concern for antitrust authorities in innovation-driven markets.

97. It is clear that the TFT-LCD production technology evolved dramatically over the damages period and that investments in new fabs drove down production costs. For example, Dell's Complaint describes the evolution of the size of the "motherglass" glass sheets that go into the production of panels:[82]

> The glass substrates used for TFT-LCD panels begin with a "motherglass," a sheet of glass that is cut to make multiple panels. TFT-

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80 Alexis Jacquemin and Margaret E. Slade (1989), "Cartels, Collusion, and Horizontal Merger," in Richard Schmalensee and Robert Willig, *eds.*, *Handbook of Industrial Organization* at 420.

81 Ivaldi *et al.* (2003) at 32-35.

82 *Dell Complaint*, ¶72.

> LCDs are manufactured in fabs that are equipped to handle a particular size motherglass. Technological innovations over time have allowed manufacturers to begin the manufacturing process with larger and larger size motherglass sheets. This, in turn, has resulted in the ability to fabricate larger and/or more TFT-LCD panels. Each increase in motherglass size is described as a generation. Third generation fabs in the 1998 to 1999 period typically utilized 550 millimeter ("mm") by 650 mm motherglass, while some current (eighth generation) fabs utilize 2160 mm by 2460 mm motherglass. The use of larger motherglass provides substantial cost savings to manufacturers.

98. This evolution also means that there will be several generations of fabs producing panels at any point in time. Figure V-1 shows the share of industry capacity accounted for by fabs of each generation, in each quarter, 1996-2010.[83] This phenomenon means that at the same point in time, both within and across firms, there will be a range of production technologies and therefore a range of production costs. This range of costs also makes reaching and maintaining a cartel agreement more problematic.

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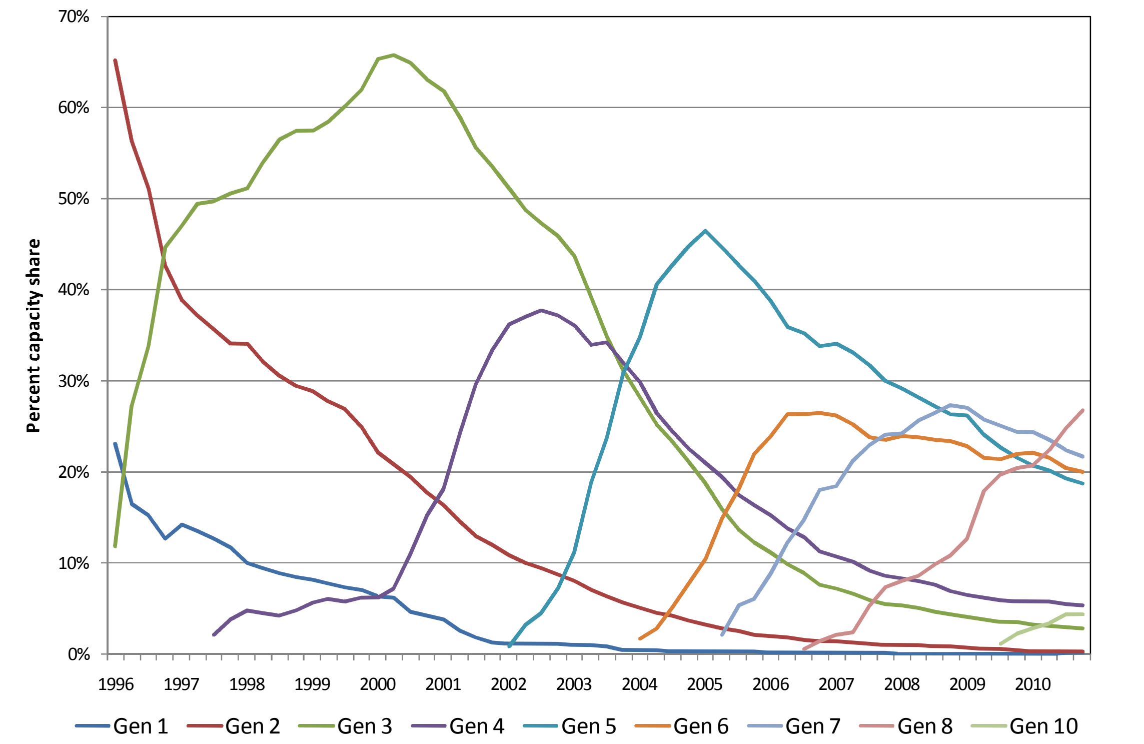
83 To simplify the figure, multiple "sub-generations" are collapsed into generations 2, 3, and 5.

Figure V-1: Share of TFT-LCD Capacity by Fab Generation, 1996Q1-2010Q4



Source: DisplaySearch capacity data, DISP_LCD_000002.

99. Rapid technological change enhances the *internal* constraints to cartel success. Even where there is no entry, rapid technological change creates an incentive for incumbents to invest in new production facilities. By doing so, they can lower their costs, improve product quality, develop new products, and generally gain an advantage over other incumbents who do not invest in the new technology. This creates an incentive for them to cheat on the cartel price and expand output in order to take advantage of their lower costs. In contrast, if firms fail to invest in new technology, they will be at a disadvantage for a considerable time relative to other firms that do invest.

100. In sum, during the period at issue, this industry underwent fundamental and rapid technological evolution of the sort that destabilizes cartels, due to the temptation facing both incumbents and potential entrants to make investments in new technology and the temptation to then expand output to take advantage of the new technology.

C. Learning by Doing

101. The TFT-LCD industry is characterized by substantial "learning-by-doing."[84] Learning by doing means that as firms gain experience operating new fabs, their production costs fall. One implication of learning by doing is that costs and prices fall as firms produce more over time, a factor that needs to be accounted for in econometric modeling of the industry. Another implication is that firms that invest in new fabs first have an incentive to set relatively low prices that enable them to expand output (and thus gain experience with those new fabs) and thereby gain substantial cost advantages over their rivals. Hence, learning by doing creates incentives to invest quickly, lower price and expand output in order to push down production costs, exactly the opposite of the incentives associated with a sustained commitment to inflated cartel prices and reduced supply.[85]

D. Product Heterogeneity and Customization

102. Economic research has demonstrated that price-fixing agreements are less successful and stable when they attempt to cover a wide variety of differentiated products.[86] Differentiation creates several problems for a cartel. First, the cartel must determine relative prices for a wide variety of goods with different demands and production costs. The more differentiation, the more difficult is this undertaking. Second, differentiation means that many prices must be fixed and the cartel must monitor all of these prices. This greatly complicates the problem of detecting cheating on cartel agreements. Third, the economic literature is clear that when products are heterogeneous,

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84 *See, e.g.,* Jeongsik Lee, Byung-Cheol Kim, Young-Mo Lim (2011), "Dynamic competition in technological investments: An empirical examination of the LCD panel industry," *International Journal of Industrial Organization*, 29:718-728 at 720.

85 *See, e.g.,* David Besanko, David Dranove, Mark Shanley, and Scott Schaefer (2004), *Economics of Strategy* at 96 for a discussion of the fact that, contrary to a cartel's desire to restrict output and thus increase prices, firms facing an important learning curve may produce *more* than would otherwise be optimal in order to gain experience and drive down production costs.

86 Valerie Suslow (2005), "Cartel Contract Duration: Empirical Evidence from Inter-war International Cartels," *Industrial and Corporate Change,* 14(5) at 722; George A. Hay and Daniel Kelley (1974), "An Empirical Survey of Price Fixing Conspiracies," *Journal of Law and Economics*, 17(1); Peter Asch and Joseph Seneca (1975), "Characteristics of Collusive Firms," *Journal of Industrial Economics*, 23(3).

changes to product characteristics may provide a way for firms to cheat on a price-fixing agreement, particularly when competing for important buyers.[87] For example, even if one accepted that firms could agree to fix prices by application, size, and resolution, they could then potentially deviate from the agreement by offering improvements in other dimensions, such as a higher percentage of higher quality panels with fewer defects, a better viewing angle, or a better contrast ratio, at the agreed-to price. This is particularly true since, to the extent that standard industry data sources (such as DisplaySearch, among others) might be considered a means to monitor prices, these sources track prices primarily by application, size, and resolution rather than other relevant characteristics.[88]

103. TFT-LCD panels are highly differentiated. In Section II, above, I describe the broad range of applications, sizes, and resolutions of TFT-LCD panels, and note that differentiation across panels ranges far beyond application, size, and resolution, to include contrast, brightness, refresh rates, viewing angle, and thickness.[89] Throughout the damages period, the Defendants sold more than 300 different panels based just on different combinations of size and display standard, with specific firms like AUO selling as many as 800 different panel models over the period covered by available data.[90]

104. The wide variety of combinations of product characteristics would have made it difficult to set and monitor prices and provided ample means for Defendants to defect from a price-fixing agreement by providing a slightly better product at an agreed-to price. It appears, in fact, that no attempt was made to specify prices of all possible combinations of characteristics. For example, as discussed in Section IV, prices discussed at Crystal

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87 *See*, Carlton and Perloff (2005) at 135. ("It is easier for a cartel to spot cheating when all it has to examine is a single price. It is relatively difficult to detect price cutting that is achieved by an increase in quality; a firm could increase its quality and hold its price constant if it wanted to increase sales without explicitly violating the pricing agreement.").

88 A sales manager at AU Optronics Corporation testified to the limitations of pricing information supplied by third parties: "Basically, we would use [industry data sources] just for basic reference, because for Wits View or Display Search, they do not include information regarding the special requirement or quality." (Deposition of Joyce Pan, Vol. I, March 9, 2009, 65:21-24.)

89 *See*, Expert Report of Janusz A. Ordover Regarding Class Certification, July 1, 2009, ¶¶40-48.

90 Calculations included in backup materials.

Meetings covered only a subset of panels of particular application, size, and resolution combinations, and ignored other characteristics. Although a few sizes were more common than others, there is a large combination of different applications, sizes, and resolutions across panels. Thus, even if a few types of panels were more common, there is great heterogeneity of products sold, and products varied in many more dimensions than were contemplated in Crystal Meeting price discussions.

105. In addition to the obvious heterogeneity of panel characteristics, there is evidence in this case that many suppliers manufactured customized panels according to their customers' needs.[91] According to LGD, Hitachi Displays, and TAEC, most of their panels were customized.[92] Similarly, "significant volume" of CMO's panels were customized.[93] Sharp "always" customized panels sold to large OEMs, but did not customize panels sold to distributors.[94]

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91 I note that the fact that a panel is customized to the needs of a particular customer does not imply the panel is ultimately sold only to that one customer. In some cases, customized panels were sold as replacement parts or to smaller customers with some flexibility in terms of design specifications. However, customized models would command a price differential over non-customized panels. (*See*, *e.g.*, Declaration of Kevin Yang in Support of Defendants' Opposition to Direct Purchaser Plaintiffs' Motion for Class Certification, June 18, 2009, ¶6) In addition, customized panels may appear in the data as being sold to several buyers because they were sold to a single customer through several different authorized service providers and contract manufacturer OEMs. (*See*, *e.g.*, Declaration of Michael Blashe in Support of Defendants' Opposition to Direct Purchaser Plaintiffs' Motion for Class Certification, June 25, 2009, ¶14.)

92 "Customized panels, meaning panels designed according to a customer's specifications, comprise over 95 percent of HDP's production and sales." (Declaration of Tadashi Yamada in Support of Defendants' Opposition to Direct Purchaser Plaintiffs' Motion for Class Certification, June 25, 2009, ¶6.) "As a 'top tier' manufacturer, LG Display generally manufactures its LCD panels to customized specifications provided by its customers under contract…." (Declaration of Yoong Ki Min, April 27, 2009, ¶¶15-16.) "The majority of TFT-LCD panels sold by TAEC are unique and customized to a customer's specifications." (Declaration of Michael Blashe in Support of Defendants' Opposition to Direct Purchaser Plaintiffs' Motion for Class Certification, June 25, 2009, ¶12.)

93 Declaration of Kevin Yang in Support of Defendants' Opposition to Direct Purchaser Plaintiffs' Motion for Class Certification, June 18, 2009, ¶6. *See also* Deposition of Kevin Yang, Vol. I, March 13, 2009, 32:11-33:22.

94 Declaration of Marshall Pinder in Support of Defendants' Opposition to Direct Purchaser Plaintiffs' Motion for Class Certification, June 25, 2009, ¶¶4 and 6.

106. Table V-1 shows some of the more common display standards that have existed over time for monitor and notebook panels. There is a wide range of pixel densities available at any point in time, and panels have evolved over time to higher resolutions. Table V-2 shows the same for TV panels.

Table V-1: Common Levels of Resolution, Monitors and Notebooks

Display Resolution	Description	Horizontal Pixels	Vertical Pixels	Total Pixels
SVGA	Super Video Graphics Array	800	600	480,000
WSVGA*	Wide Super Video Graphics Array	1,024	600	614,400
XGA	Extended Graphics Array	1,024	768	786,432
HD720	High-Definition 720	1,280	720	921,600
WXGA*	Wide Extended Graphics Array	1,280	768	983,040
WXGA+	Wide Extended Graphics Array Plus	1,440	900	1,296,000
SXGA	Super Extended Graphics Array	1,280	1,024	1,310,720
SXGA+	Super Extended Graphics Array Plus	1,400	1,050	1,470,000
WSXGA+*	Wide Super Extended Graphics Array Plus	1,680	1,050	1,764,000
UXGA	Ultra Extended Graphics Array	1,600	1,200	1,920,000
HD1080	High-Definition 1080	1,920	1,080	2,073,600
WUXGA*	Wide Ultra Extended Graphics Array	1,920	1,200	2,304,000

Sources: Defendants' transaction data and "Display Standardization.xlsx."

*The data show that some Defendants also produced panels with different resolutions (for the same display standard name).

Table V-2: Common Levels of Resolution, TVs

Display Resolution	Description	Horizontal Pixels	Vertical Pixels	Total Pixels
VGA	Video Graphics Array	640	480	307,200
XGA	Extended Graphics Array	1,024	768	786,432
HD720	High-Definition 720	1,280	720	921,600
WXGA*	Wide Extended Graphics Array	1,280	768	983,040
WXGA+	Wide Extended Graphics Array Plus	1,440	900	1,296,000
WSXGA+	Wide Super Extended Graphics Array Plus	1,680	1,050	1,764,000
HD1080	High-Definition 1080	1,920	1,080	2,073,600
WUXGA	Wide Ultra Extended Graphics Array	1,920	1,200	2,304,000

Sources: Defendants' transaction data and "Display Standardization.xlsx."

*The data show that some Defendants also produced panels with different resolutions (for the same display standard name).

E. SUBSTANTIAL NEW PRODUCT INTRODUCTION

107. As discussed above, industries experiencing rapid technological change will find it more difficult to maintain a price-fixing agreement. One particular aspect of technological innovation in the TFT-LCD industry is the steady introduction of new panels. The introduction of new panels not only makes reaching and maintaining a cartel agreement problematic, but also facilitates cheating on the alleged cartel agreement. New product introductions provide an incentive to cheat through the prospect of profits on substantial sales of a new product, for which there is no price agreement. In addition, new product introductions increase heterogeneity in terms of quality and functionality, limiting competitors' ability to detect a price decrease.

108. Defendants frequently introduced panels with new sizes or resolutions for which there is no evidence of previous price discussions. Even if a new panel is eventually discussed, the initial introduction of the new product could represent an effective price reduction. A participant could cheat on an agreement to fix the price of an existing panel by lowering its price or by introducing a new panel that is more attractive to customers than the existing panel (for example, because the new panel has similar characteristics but a lower price or because an innovative panel has more value for customers but it is offered at a similar price which reduces the appropriately quality-adjusted price).

109. The evidence in this case shows that Defendants introduced hundreds of new panels during the years of the alleged conspiracy.

110. Figure V-2 shows the introduction of all monitor panels with more than $100 million in sales during the 1999-2006 period. As the size of the motherglass increased over time, Defendants introduced larger monitor panels. In addition, Defendants introduced new panels that were not larger but had different resolutions.[95]

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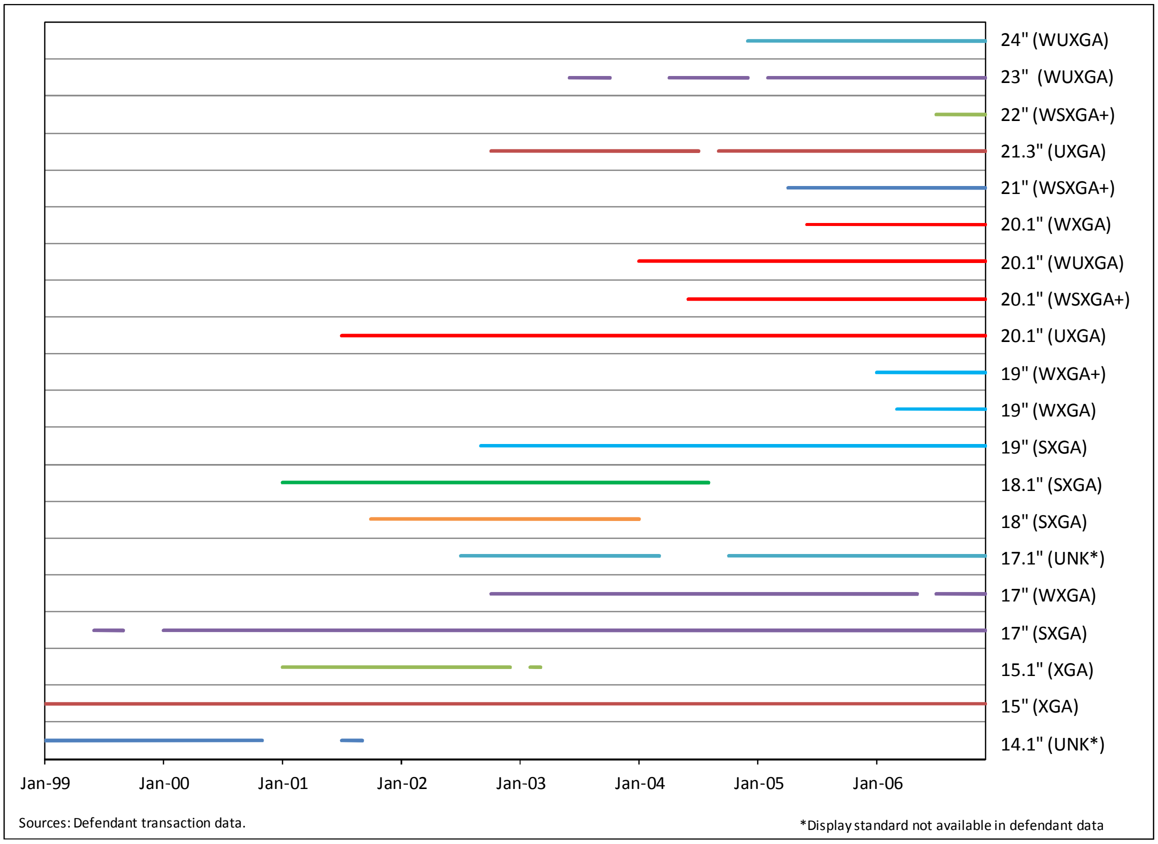
95 For some panels, the Defendants' transaction data do not identify a display standard. In the charts that follow, I have listed a panel with no data on display standard as a new panel *only if* there is no other panel of the same size.

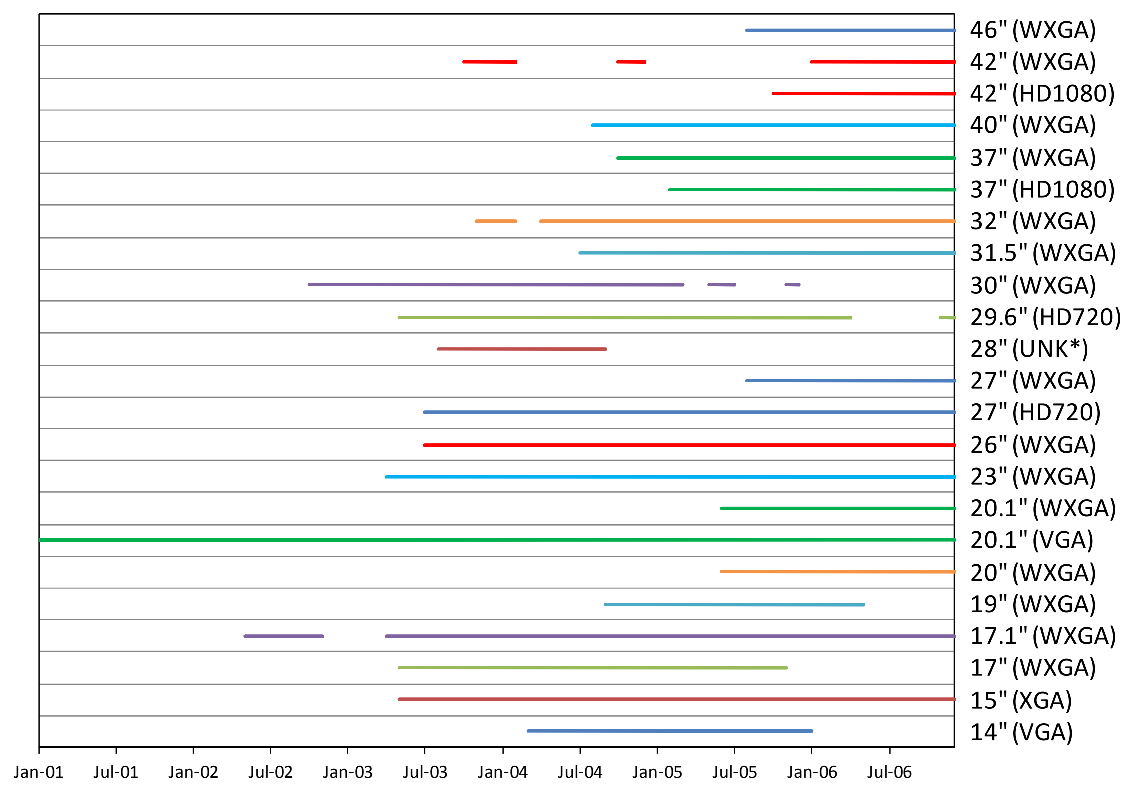
Figure V-2: Top Selling Monitor Panels



111. For example, the 15" XGA monitor panel was one of the top selling panels during the 1999-2006 period. It was sold by most suppliers and was one of the most frequently discussed at the Crystal Meetings. However, during 2001-2002, LGD was also selling a slightly larger monitor panel, a 15.1" XGA panel, at a similar price. During these years, LGD sold similar amounts of both panels, approximately $400 million of each panel size. I am not aware of any price discussion related to the 15.1" XGA panel. Furthermore, DisplaySearch does not include any 15.1" panel in its panel shipment dataset. As such, LGD potentially could have used the 15.1" panel to evade the price agreement on the 15" panel by offering a larger monitor at a similar price.

112. Similarly, during the 2003-2005 period, Defendants introduced about 30 new TV panels with different size-resolution combinations. Figure V-3 shows the timing of the introduction of all TV panels with more than $50 million in sales during the 1999-2006 period. As with monitor panels, Defendants introduced larger TV panels over time, but also introduced new panels of intermediate sizes or different resolutions.

Figure V-3: Top Selling TV Panels



Sources: Defendant transaction data. *Display standard not available in defendant data.

113. Given the large number of different mobile panels, and the extent to which new panels were introduced each year, it would be surprising if the alleged cartel was successful in raising price significantly.

F. INDUSTRY DYNAMISM

1. Entry

114. The entry of new firms in an industry is disruptive to a cartel.[96] The disruptive effect of entry *that occurred in the TFT-LCD industry during the damages period* is acknowledged by Plaintiffs. For example, in discussing the rapid price declines during 2000-2001, the Dell Complaint notes that:[97]

96 *See*, Margaret C. Levenstein and Valerie Y. Suslow (2004), "Studies of Cartel Stability: A Comparison of Methodological Approaches," in Peter Z. Grossman, *ed.*, *How Cartels Endure and How They Fail,* Table 1.11.

97 *Dell Complaint*, ¶171.

> By January of 2000, prices for TFT-LCD Products were falling again. The price decline in this period was substantially influenced by the entry of six new Taiwanese competitors, including Chi Mei, Chunghwa, HannStar, and Acer Display Technology, Inc. (later part of AU Optronics).

Substantial entry occurred in the TFT-LCD industry during the damages period. As shown in Table V-3, some Taiwanese suppliers (*e.g.*, AUO) entered in the 1999-2010 period and grew their shares over time, and other companies (*e.g.*, Epson, Innolux) entered at a small scale and remained small.

Table V-3: Share of Industry Revenues, by Manufacturer, All Applications, 1999-2010

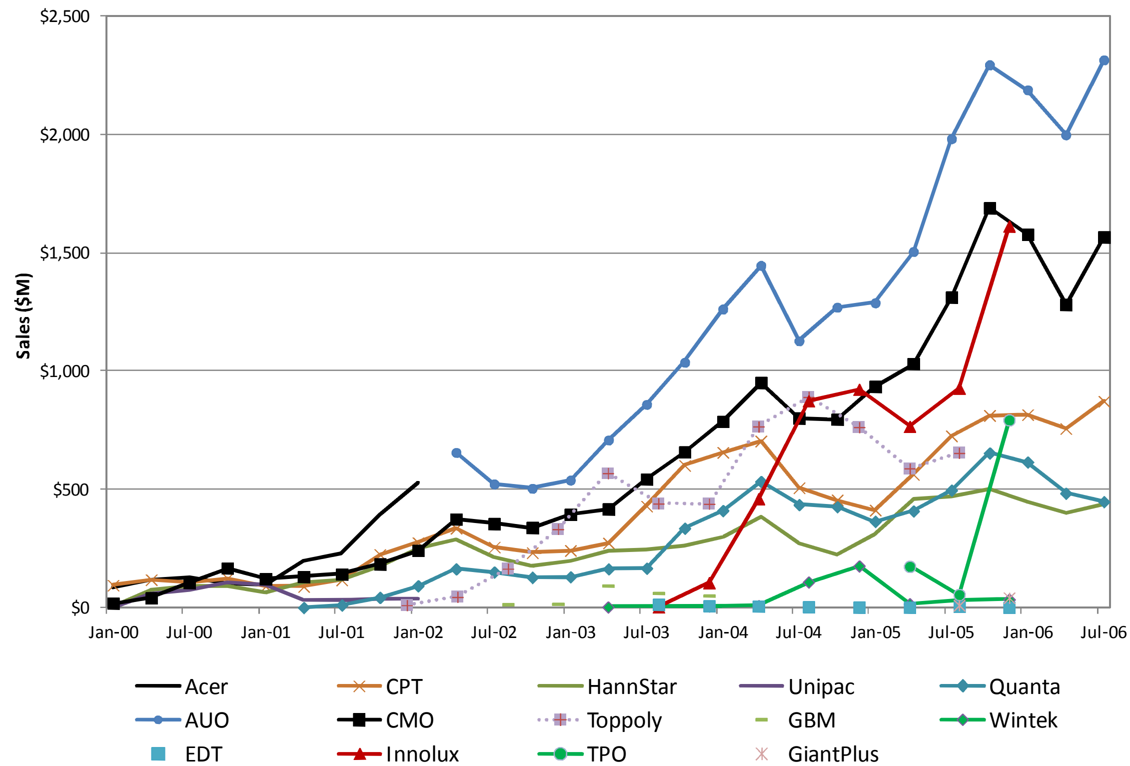
TFT-LCD Supplier	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
AUO				8.51%	10.51%	10.75%	11.73%	13.62%	16.70%	15.15%	13.97%	14.03%
Acer	1.95%	3.18%	7.57%	2.67%								
Alps							0.03%	0.01%				
BOE Hydis	1.90%	2.63%	2.90%	3.44%	2.46%	1.41%	1.94%	1.55%	1.49%	1.12%	1.04%	0.99%
BYD									0.08%	0.15%	0.18%	0.23%
CMO	0.12%	2.41%	4.76%	6.62%	8.62%	7.94%	8.42%	8.86%	10.23%	11.55%	11.81%	2.77%
CPT	2.82%	3.20%	4.29%	5.56%	5.16%	4.89%	4.17%	4.97%	5.10%	3.75%	2.17%	2.37%
Casio		0.24%	1.20%	0.94%	1.33%	1.06%	0.88%	0.64%	0.52%	0.32%	0.17%	0.04%
Chimei Innolux												10.60%
EDT						0.01%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%
Epson						1.06%	3.82%	2.78%	1.81%	1.57%	0.87%	0.15%
Fujitsu	2.95%	2.52%	1.35%	0.68%	0.39%	0.25%	0.03%					
GBM						0.11%	0.02%					
GiantPlus								0.04%	0.05%	0.28%	0.48%	0.36%
HannStar		1.87%	3.81%	4.69%	3.16%	2.47%	2.88%	2.57%	2.66%	1.95%	1.80%	1.61%
Hitachi	11.34%	10.11%	7.26%	5.71%	4.54%	3.70%	1.96%	1.80%	1.60%	1.90%	1.53%	1.34%
Hyundai					0.08%	0.01%	0.03%	0.00%	0.01%	0.00%		
IPSAlpha								0.37%	1.20%	1.64%	1.42%	0.34%
Infovision								0.05%	0.52%	0.45%	0.80%	0.96%
Innolux						0.00%	1.10%	1.93%	1.95%	1.62%	2.24%	0.64%
Kyocera							0.02%	0.02%	0.06%	0.08%	0.05%	0.11%
LG Display	16.87%	14.66%	15.39%	14.67%	17.76%	15.85%	16.56%	15.99%	16.90%	16.70%	20.16%	21.44%
LG Innotek						0.69%	0.94%	0.52%	0.43%	0.40%	0.36%	0.10%
Matsushita	3.07%	2.37%	0.79%	0.06%								
Mitsubishi/ADI	3.73%	2.93%	1.65%	1.12%	0.64%	0.23%	0.19%	0.19%	0.18%	0.12%	0.12%	0.14%
NEC	8.16%	6.54%	3.83%	1.99%	1.09%	0.68%	0.68%	0.34%	0.26%	0.21%	0.18%	0.17%
Optrex				0.02%	0.16%	0.30%	0.36%	0.29%	0.14%	0.15%	0.12%	0.18%
Ortus												0.13%
Others		0.02%	0.11%	0.10%	0.33%	0.38%	1.13%	0.52%	0.26%	0.08%	0.06%	0.13%
PVI									0.15%	0.22%	0.38%	0.54%
Panasonic LCD												1.33%
Philips				0.14%	0.53%	0.60%	0.92%	0.51%				
Philips Kobe	1.13%	1.21%	0.09%									
Quanta			0.44%	2.70%	2.66%	3.80%	3.19%	2.22%				
SII					0.03%	0.46%	0.38%	0.34%	0.26%	0.22%	0.11%	0.08%
ST LCD		0.15%	2.15%	1.69%	2.55%	1.82%	1.40%					
SVA NEC						0.00%	0.87%	1.17%	1.12%	0.90%	0.20%	0.00%
Samsung	20.95%	21.57%	19.60%	16.51%	18.21%	20.48%	19.28%	21.55%	20.69%	22.11%	24.54%	22.77%
Sanyo	4.82%	3.90%	3.68%	3.22%	2.48%	1.58%						
Sharp	9.65%	8.33%	10.08%	10.30%	9.53%	12.70%	11.14%	10.55%	9.70%	10.92%	9.07%	10.72%
Sony	5.42%	5.34%	4.29%	2.62%			0.18%	1.50%	1.11%	1.10%	0.65%	1.18%
TMDisplay				5.30%	7.74%	5.87%	4.27%	3.78%	2.91%	2.91%	2.30%	2.02%
TPO								0.74%	1.09%	1.18%	1.19%	0.15%
Tianma									0.10%	0.06%	0.63%	1.01%
Toppoly					0.05%	0.89%	1.33%	0.50%				
Toshiba	5.11%	5.06%	3.13%	0.55%								
Truly									0.40%	0.63%	0.68%	0.72%
Unipac		1.76%	1.61%	0.18%								
Wintek						0.00%	0.14%	0.05%	0.32%	0.56%	0.73%	0.63%
Total Share of Suppliers with Less Than 5% Share	**22%**	**28%**	**40%**	**27%**	**22%**	**26%**	**33%**	**29%**	**21%**	**24%**	**20%**	**20%**
- Number of suppliers with Less Than 5% Share	**9**	**14**	**17**	**17**	**16**	**24**	**27**	**28**	**27**	**28**	**27**	**30**

Source: DisplaySearch panels data, DISP_LCD_000001.

115. Figure V-4 is a chart of total 2000-2006 TFT-LCD revenues of Taiwanese suppliers. The chart shows the entry of Quanta and the growth of Hannstar, CPT, CMO

and AUO during the 2000 - 2003 period, and the entry of Giantplus, Infovision, GMP, Optrex, TPO Toppoly, and Innolux during the 2004 – 2006 period.

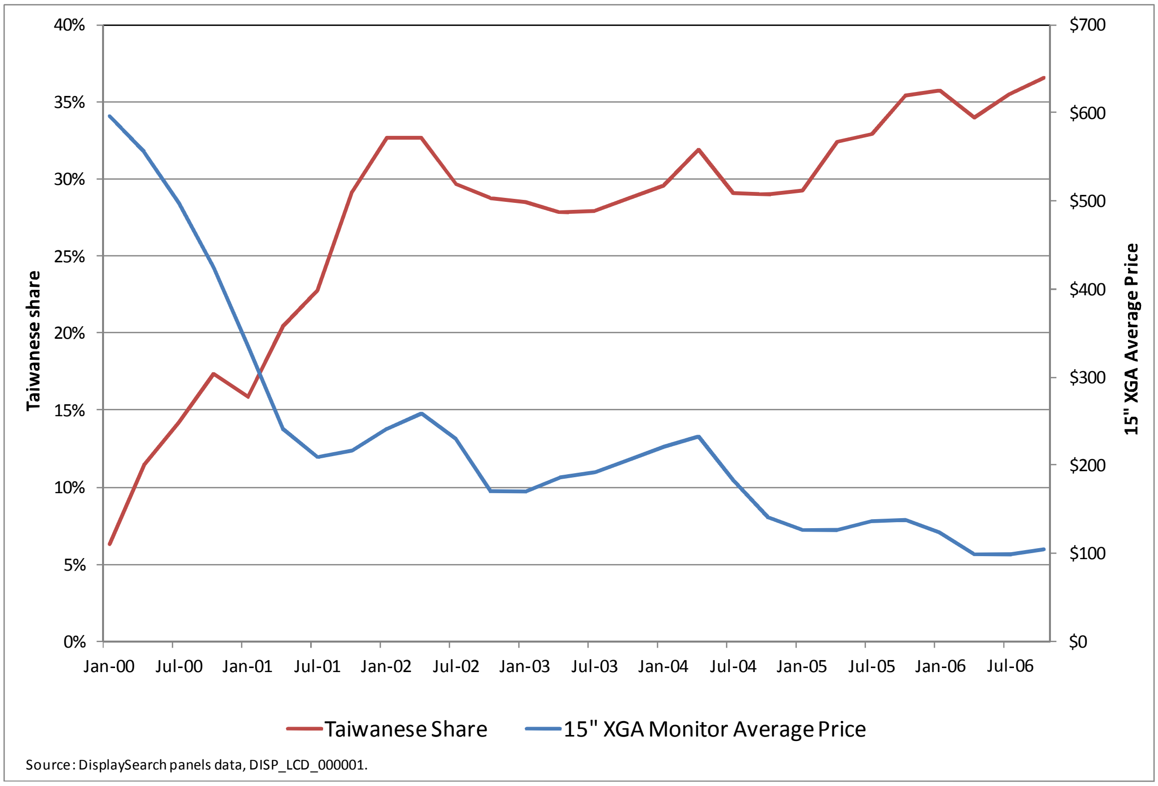
Figure V-4: TFT-LCD Sales of Taiwanese Suppliers, 2000-2006



Source: DisplaySearch panels data, DISP_LCD_000001.

116. Figure V-5 is a chart of TFT-LCD industry prices and Taiwan's share of revenues, which shows a declining average price of the 15" (XGA) monitor panel corresponding with Taiwan's growth in volume. In particular, the figure shows that the average price of a 15" (XGA) monitor panel dropped from approximately $600 in early 2000 to less than $300 in 2001, corresponding with the rapid increase in the share of Taiwanese producers from less than 10 percent in January 2000 to approximately 30 percent by January 2002.

Figure V-5: Taiwanese Share of TFT-LCD Sales and 15"XGA Monitor Price, 2000-2006



2. Capacity Growth

117. Capacity expansion among existing firms is also disruptive to a cartel. As explained in a recent report to the European Competition Commission:[98]

> [O]ften capacity choices are not a continuous phenomenon, but come in infrequent bursts, at points in times that may differ from one firm to another. Such choices then involve less frequent interactions than price decisions. As already pointed out, the infrequency of such interaction is a factor that impedes collusion. The "lumpiness" aspect of capacity building leads to pre-emption phenomena: when a market opportunity arises or simply when demand is growing, firms compete for being the first to build capacity…the capacity choice of one firm affects the market for a very long time. In this context pre-emption phenomena may be particularly acute. Indeed, when capacity decisions are fully irreversible, a firm that deviates from a collusive conduct will impose a "fait accompli" on its competitors, who may have no choice left other than adapting themselves to this new situation.

98 Ivaldi *et al.* (2003) at 60-61.

118. As discussed above in Section II, this race to build new capacity characterizes the TFT-LCD industry. As noted by one industry analyst:[99]

> TFT LCD is a business that requires continuous capital investment because of the unique semiconductor process on TFT array fabrication and highly automated production handling process. Faced with the rapid migration in substrate size and technology, intensive investment is needed to keep up with the competition.

119. Indeed, substantial capacity expansion occurred in the industry during the damages period.[100] At the beginning of the damages period in 1999, the industry had a total production capacity of about 212 thousand square meters of glass per month. By the end of the damages period in late 2006, capacity had grown to almost 30 times that amount, to about 5,950 thousand square meters of glass per month.[101] (*See* Figure V-6.)[102] This massive increase in capacity during (and after) the damages period would increase the difficulty for a cartel to succeed in raising price significantly.[103]

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99 UBS Warburg, "TFT-LCD Industry Update," September 16, 2002 at 6.

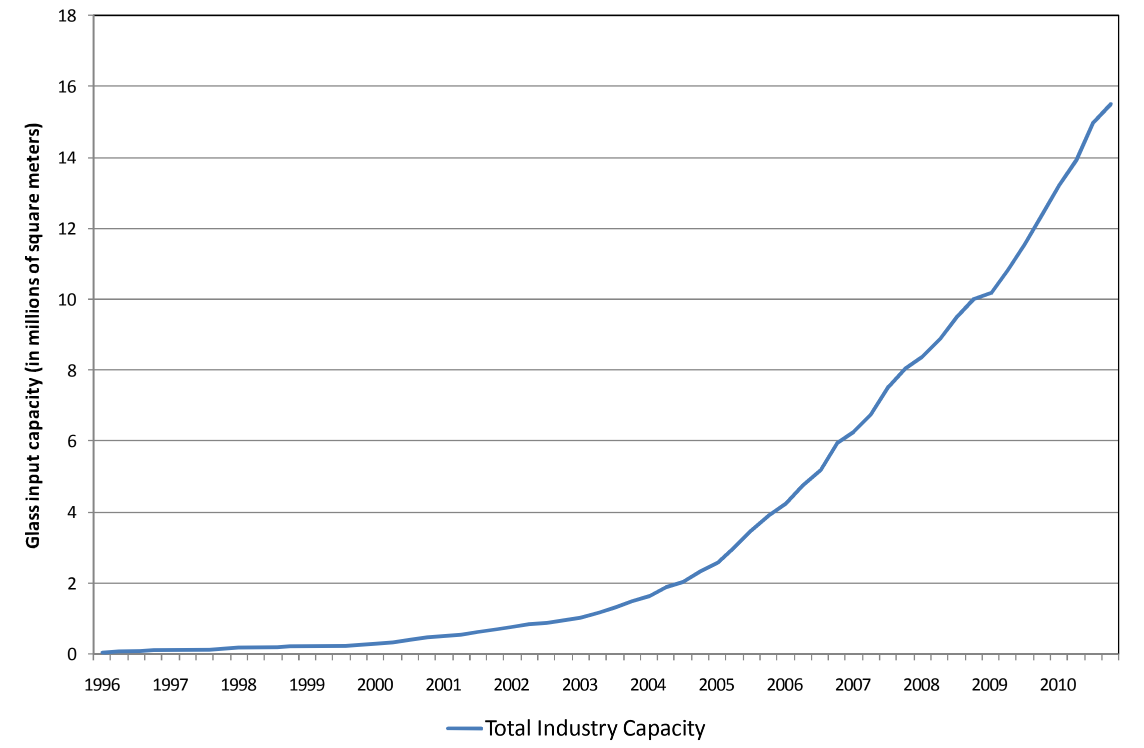
100 Industry data showing capacity expansion is buttressed by testimony that many firms were investing in new fabs. (*See* Deposition of Jau-Yang Ho, Vol. II, June 17, 2011, 270:6-18.) Data from Capital IQ show $40 billion in capital expenditures by five Defendants (AUO, CMO, CPT, HannStar, and LGD) during the 2000-2006 period.

101 Source: DisplaySearch capacity data, DISP_LCD_000002. Capacity is measured as the maximum square meters of panels producible per month. I am not claiming that the fact that capacity grew disproves the notion that there was an alleged conspiracy to restrict capacity; for such a determination, one would have to build a model of capacity in the but-for world, which was not done here.

102 Figure V-6 is similar to the graph *Stowell Report*, Table 1, which shows a 55 percent compound annual growth rate (CAGR) in capacity during the 1996-2006 period.

103 Dr. Rao (*Rao Report*, Tab 18) shows that capacity of TFT-LCD panels more than doubled between 2007 and 2010. Dr. Connor states "[t]he TFT-LCD industry is characterized by rapidly falling manufacturing costs that led to declining prices. Lower manufacturing costs were achieved mainly through building new plants that incorporated more efficient production methods…However, these observations do not imply that capacity expansions occurred at the optimal, possibly more rapid rate for the industry." (*Connor Report*, ¶25-26)

Figure V-6: Quarterly Industry Capacity, 1996Q1-2010Q4



Source: DisplaySearch capacity data, DISP_LCD_000002.

120. Indeed, contrary to any claim that the Defendants conspired to restrict capacity, there is no evidence that the rate of capacity formation slowed during the damages period compared to the pre- or post-damages period. In fact, as shown in Figure V-7, the rate of capacity growth was *higher* during the damages period than either before or after the damages period. Capacity increased at an annual rate of 45.7 percent before the damages period, 52.5 percent during the damages period, and 27.1 percent after the damages period.[104, 105]

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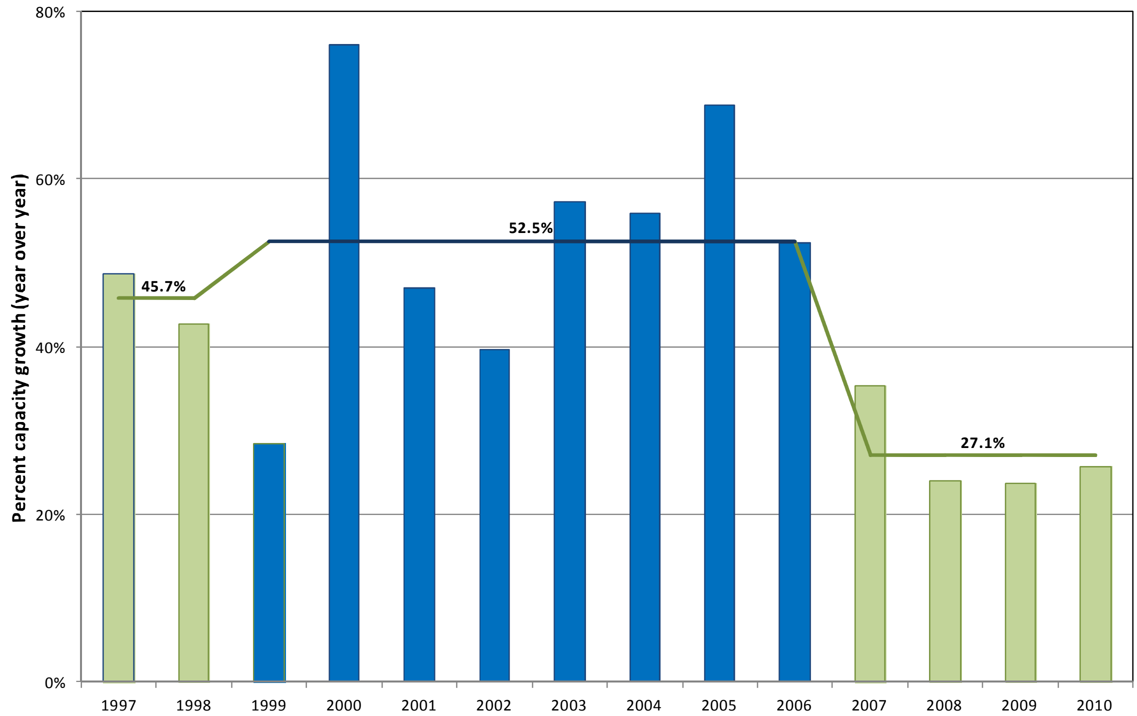
104 Growth calculations are compound annual growth rates from the beginning to the end of the pre-damages, damages, and post-damages periods.

105 I also analyzed the results in Figure V-7 under the assumption that there is a one or two-year lag to bring a fab online (*i.e.*, assuming Defendants had no flexibility to shut down investment or slow the rate at which fabs were brought online, so a two-year lag would mean that cartel capacity expansion is reflected in years 2001-2008 rather than 1999-2006). I found that there was no material reduction in the rate of capacity expansion after the alleged cartel began, but there was a substantial reduction in the rate of capacity expansion after the alleged cartel ended, which is not what one would expect if the cartel had been successfully restraining capacity investment. Of course, simply looking at growth rates of capacity growth in two periods does not adjust for the influences of other factors.

Figure V-7: Industry Capacity, Year-over-Year Growth Rate and CAGR (Pre-Damages, Damages, and Post-Damages Periods)



Source: DisplaySearch capacity data, DISP_LCD_000002.
Note: Average growth rate in each period (pre-class, class, and post-class), calculated as the Compound Annual Growth Rate.

121. The fact that capacity growth did not slow during the alleged cartel period is not surprising: As described in Ivaldi *et al*. (2003), agreements on restricting capacity are especially difficult to implement in an industry where capacity is lumpy.[106] Indeed, there is a significant incentive to cheat on an agreement, as building a new fab with new generation technology can significantly lower production costs, thus creating further incentives to expand output and cheat on any cartel agreement.

3. Shifting Market Shares

122. The difficulty in maintaining a successful cartel is increased when shares of the cartel members change over time. Shifting shares make it difficult for an alleged cartel to reach *initial terms of agreement* and undermine stability as Defendants' interests diverge. This follows because a cartel agreement involves a reduction in aggregate output (relative to the non-cartel level) in return for elevated aggregate profit (relative to the non-cartel level). This means that the alleged cartel must have a mechanism for allocating the

106 Ivaldi *et al.* (2003) at 60-61.

benefits across its members. When shares are shifting over time, development and maintenance of the allocation mechanism can become complicated.[107]

123. Shifting shares further complicates cartel stability by increasing the difficulty in detection of cheating on any agreement that is reached. As firms' shares shift over time as a result of demand fluctuations, it is more difficult for a firm to detect whether a decrease in its sales is the result of another firm cheating on the alleged cartel price.

124. In addition, evidence of shifting market shares indicate that the alleged cartel members have not implemented what is known to be one of the most effective ways of organizing a successful cartel: fixed market shares.[108]

> Fixing market shares is probably the most efficient of all methods of combating secret price reductions. No one can profit from price-cutting if he is moving along the industry demand curve, once a maximum profit price has been chosen. With inspection of output and an appropriate formula for redistribution of gains and losses from departures from quotas, the incentive to secret price-cutting is eliminated.

For example, in the vitamins cartel, participants were assigned production shares equal to their market shares prior to the cartel's formation.[109] The companies met periodically to exchange production records, and companies whose shares exceeded their allowance were required to sell—at cost—the excess production to another company which had produced less than its share. Thus a firm producing in excess of its quota could not gain profit on its excess production. As seen in Figure V-8 through Figure V-12, neither Defendants' shares of capacity nor their shares of revenue display stability over time.

125. When considering capacity shares, I observe that, while some manufacturers grew their shares substantially over this period, other saw their shares decline. The capacity shares of AUO, LGD, Samsung, and CMO increased over the damages period, while those of Sharp, Toshiba, and Hitachi Displays declined. At the beginning of the damages

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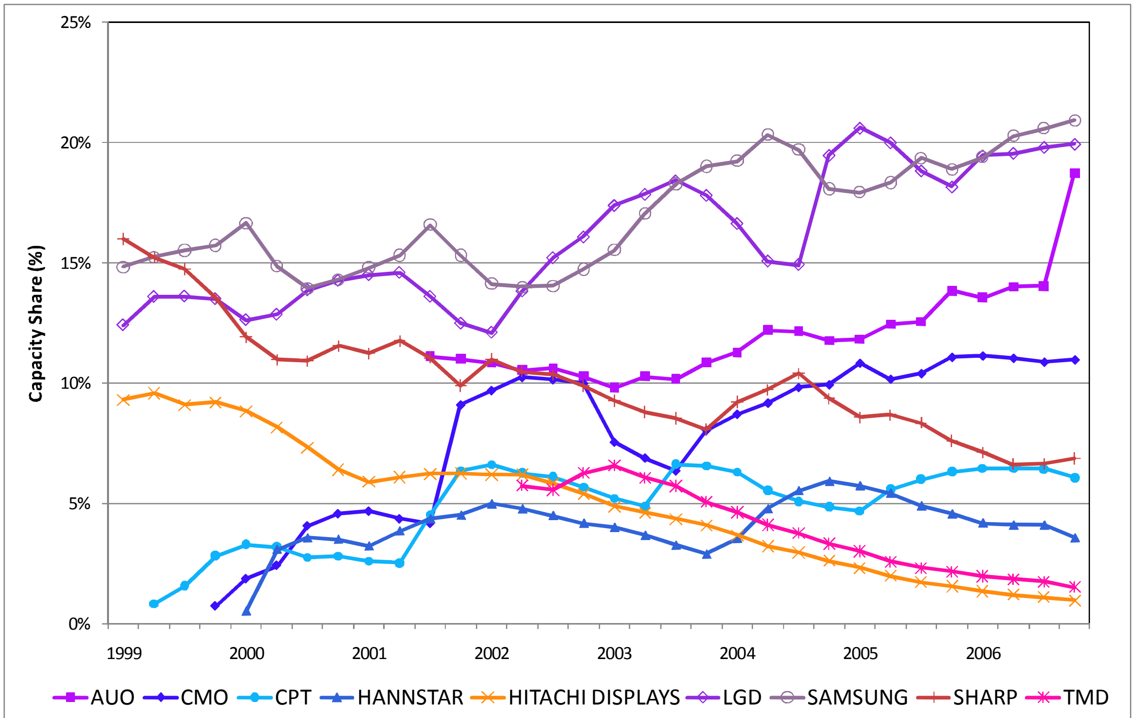
107 I have seen no evidence presented by Plaintiff Experts indicating communication related to allocation of the alleged cartel's benefits.

108 George J. Stigler (1964), "A Theory of Oligopoly," *Journal of Political Economy* 72(1) at 4.

109 The vitamins cartel was a series of cartels involving many of the same participants; not every cartel had exactly the same structure. For a discussion of the structure of the vitamins cartel, *see*, Carlton and Perloff (2005) at 142-143.

period, Sharp had the largest share of capacity, but by the end, Sharp was only the fifth largest. CMO was the smallest of the Defendants in 1999, but had grown to be the fourth largest by the end of the damages period.

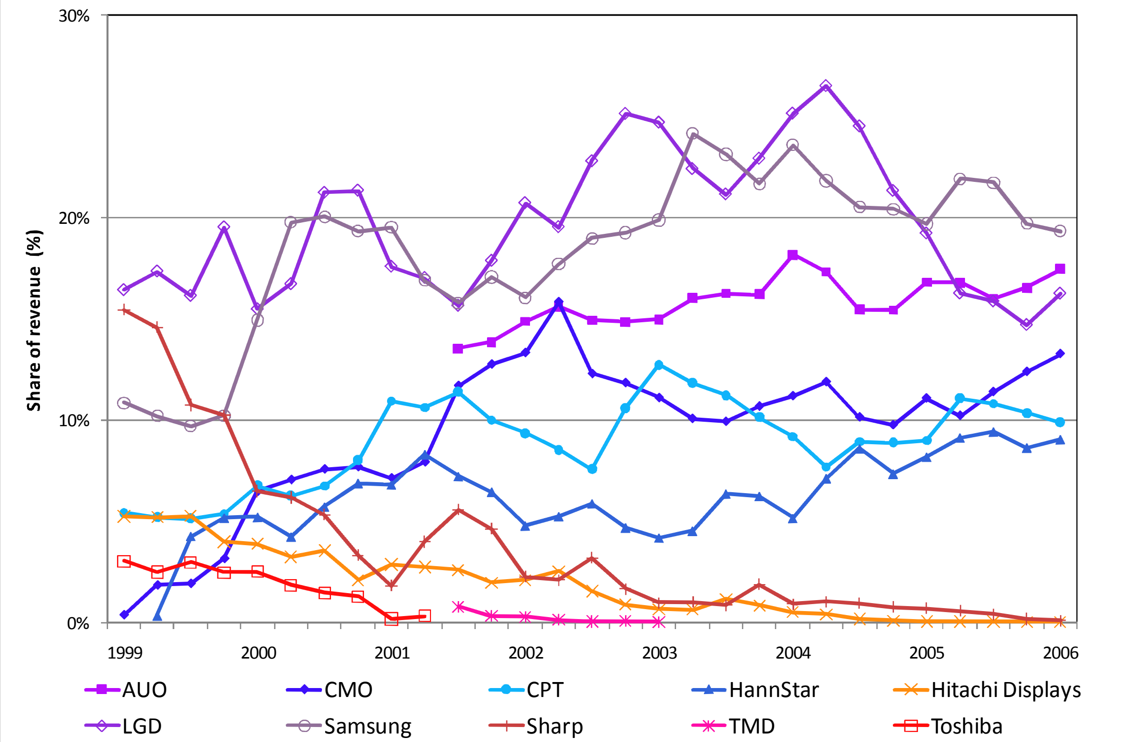
Figure V-8: Defendant Capacity Shares, 1999Q4-2006Q4



Source: DisplaySearch capacity data, DISP_LCD_000002.
Note: Acer and Unipac capacity prior to AUO's formation in 2001 Q3 not shown.

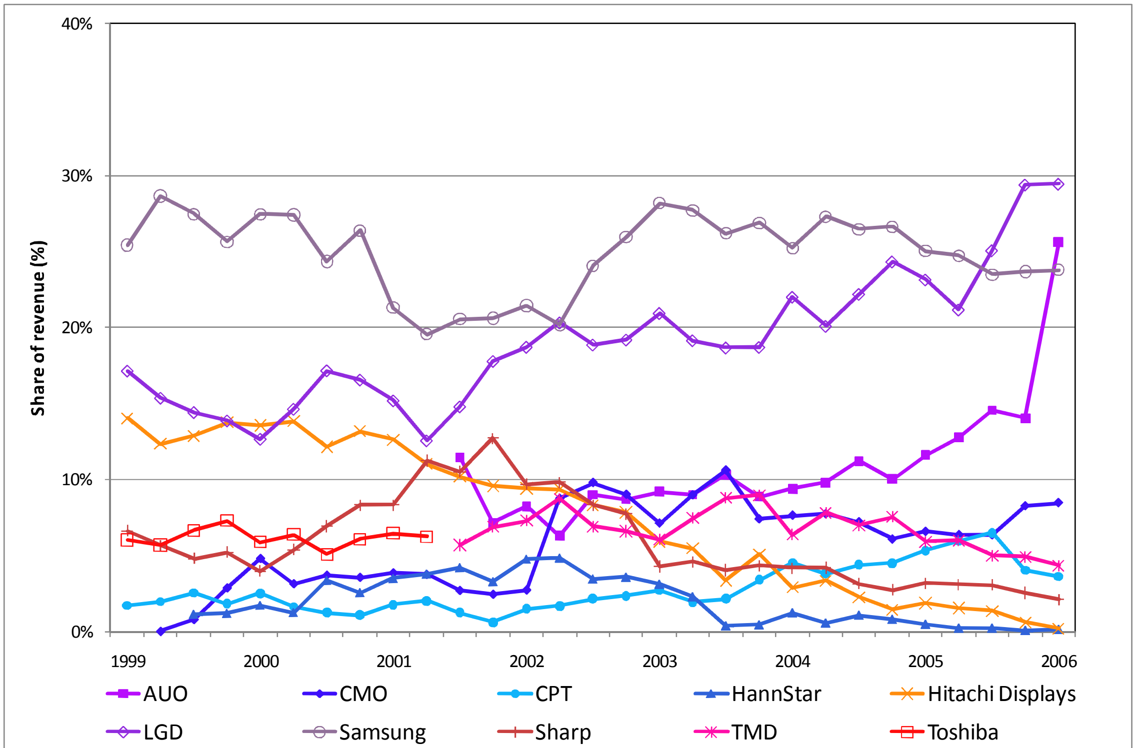
126. As seen in Figure V-9 through Figure V-12, the same dynamics are observed when studying revenue shares overall and within particular applications.

Figure V-9: Defendant Revenue Shares, Monitors, 1999Q4-2006Q4



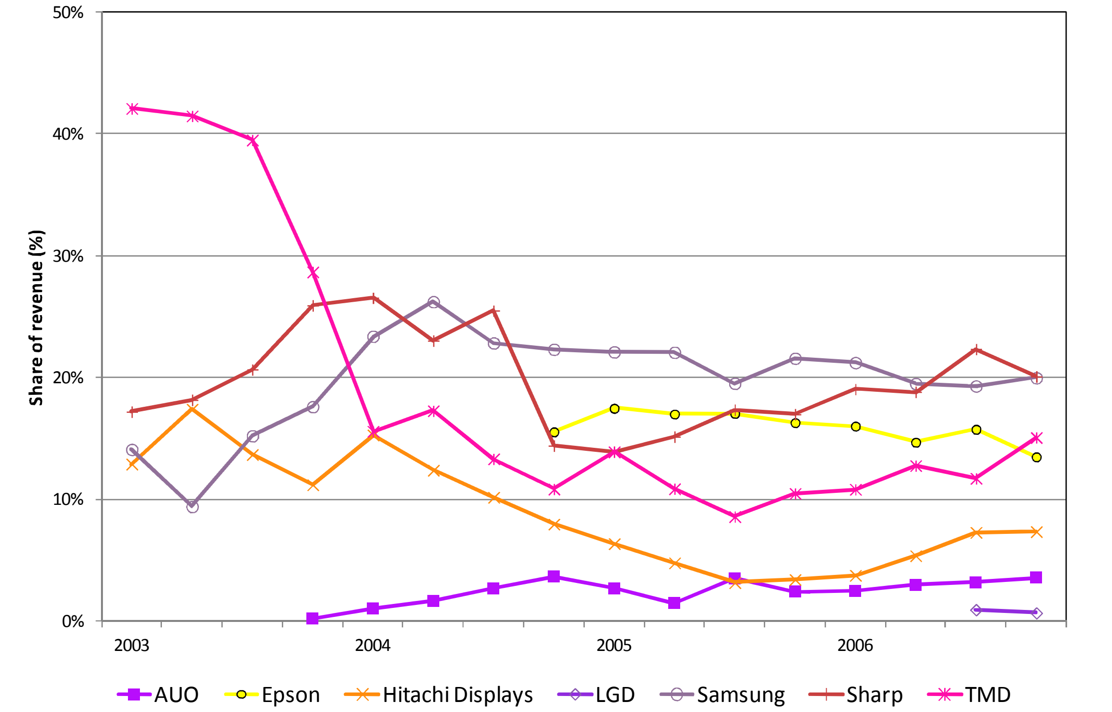
Source: DisplaySearch panels data, DISP_LCD_000001.

Figure V-10: Defendant Revenue Shares, Notebooks, 1999Q4-2006Q4



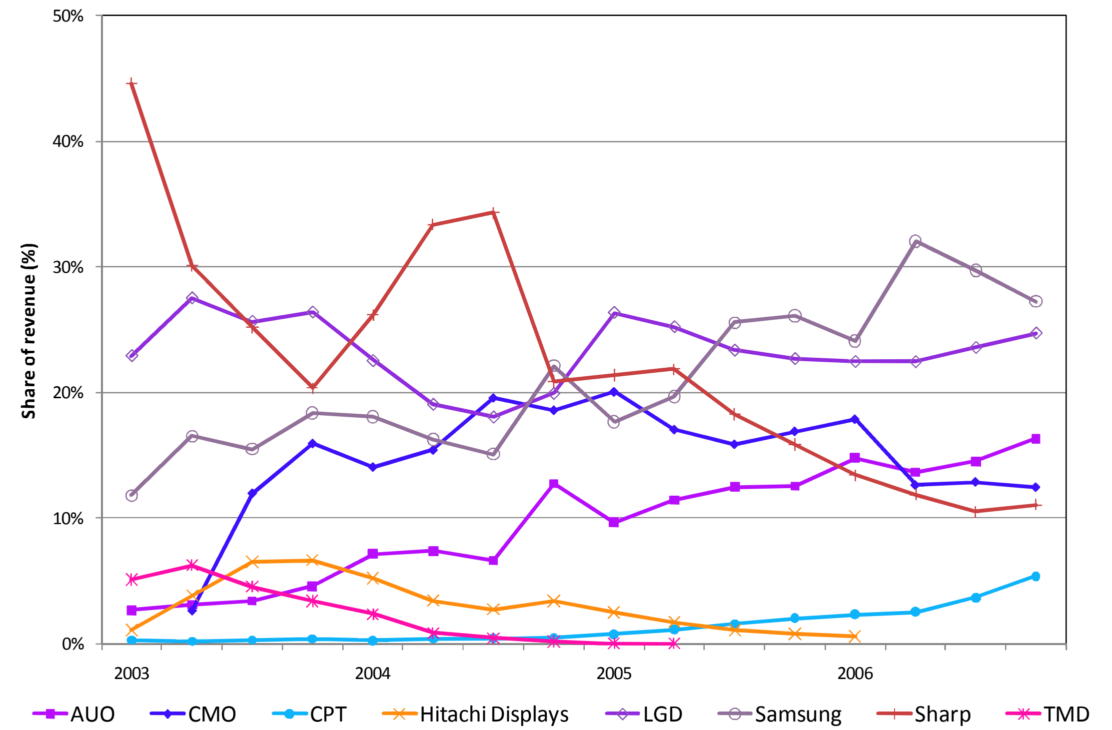
Source: DisplaySearch panels data, DISP_LCD_000001.

Figure V-11: Defendant Revenue Shares, Mobile Phones, 2003Q1-2006Q4



Source: DisplaySearch panels data, DISP_LCD_000001.

Figure V-12: Defendant Revenue Shares, TVs, 2003Q1-2006Q4



Source: DisplaySearch panels data, DISP_LCD_000001.

G. Large Number of Firms and Unconcentrated Industry

127. Implementing and maintaining a cartel is more difficult when there are a large number of firms participating in the cartel. This is so because the more firms that participate in a cartel, the more complex are the tasks of reaching agreements and monitoring compliance with such price-fixing agreements. In this matter, at least a dozen separate entities, not including co-conspirators, are alleged to have participated in the agreements.

128. In addition, all else equal, the more firms in an industry (*i.e.*, the less concentrated is the industry) the less likely it is that a price-fixing conspiracy will be successful. A comprehensive survey of empirical studies of cartels observes:[110]

> Virtually all studies of collusion include some measure of concentration. Concentration has been shown to be consistently and positively related to collusive success.

129. Using standard measures of concentration, the TFT-LCD industry is unconcentrated.[111] Concentration is often measured using the Herfindahl-Hirschman Index (HHI), which is calculated as the sum of the squares of the individual firm's market shares. The Horizontal Merger Guidelines issued by the federal antitrust agencies characterize an industry with an HHI of less than 1500 as being "unconcentrated."[112] Measuring concentration using sales shares, the TFT-LCD industry HHI ranged from 950 to 1253 in the years between 2001 and 2006, with an average of less than 1100.[113] These HHIs fall well within the Merger Guidelines' definition of an unconcentrated industry.

110 Levenstein and Suslow (2004) at 34.

111 Concentration and its measurement are explained in U.S. Department of Justice and the Federal Trade Commission, "Horizontal Merger Guidelines," § 5.

112 U.S. Department of Justice and the Federal Trade Commission (2010), "Horizontal Merger Guidelines," § 5.3.

113 The HHI in each quarter is calculated using sales reported to DisplaySearch. (Source: DisplaySearch panels data, DISP_LCD_000001.) The reported average over the 2001-2006 time period is calculated as an unweighted average of the HHI in each quarter during this time period.

H. Vertical Integration

130. As I have noted elsewhere, a cartel agreement is easier to enforce if:[114]

> [A]ll cartel members sell identical products at the same point in the distribution chain. … If some firms are *vertically integrated* … it may be difficult for the cartel to determine at what point in the distribution chain cheating occurs.

The problem that vertical integration creates for cartel success is the following: if the product at issue is not only sold by cartel members as an intermediate good but also used by cartel members in the production of further finished products, (*i.e.*, if at least some of the cartel members are vertically integrated into *production* of the finished product), then monitoring adherence to cartel prices becomes more difficult. In the present case, a vertically integrated producer of monitors, notebook computers, televisions, or mobile phones could cheat on an agreement to fix the price of the intermediate panels either by lowering the price of the panels it sells *or* by not increasing the price of finished product commensurate with an agreed-upon increase in panel prices. Since panels are but one component of the total cost of the finished product, it may be difficult to know if a vertically integrated firm is "passing through" the alleged cartel's overcharges in the prices of its finished products.

131. Varying degrees of vertical integration are prevalent in the TFT-LCD industry. Many of the Defendants sell televisions (*e.g.*, Sharp and Hitachi), computer monitors (*e.g.*, Sharp), notebook computers (*e.g.*, Sharp and Toshiba) or mobile phones (*e.g.*, Samsung) containing TFT-LCD panels. Of course, not all Defendants are vertically integrated into all downstream products, but the different degrees to which the Defendants are vertically integrated create conflicting incentives and complicate the monitoring of the alleged agreements.

I. Buyer Heterogeneity

132. Buyers are heterogeneous when they purchase different panels (*i.e.,* panels for different applications as well as panels with different characteristics or specifications for a single application), and in different volumes. They also are heterogeneous when they

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114 Carlton and Perloff (2005) at 136-139.

purchase on different terms, including the use of specialized procurement practices that may reflect differences in information possessed by different buyers, differing degrees of price sensitivity, or differences in bargaining power.

133. Economists have long noted that significant buyer heterogeneity greatly increases the difficulty of reaching and enforcing cartel agreements, thus hindering a cartel's ability to raise prices significantly. As explained by Stigler (1964):[115]

> The heterogeneity of purchase commitments (buyers), however, is surely often at least as large as that of products within an industry, and sometimes vastly larger. There is the same sort of personal differential of buyers as of sellers—ease in making sales, promptness of payment, penchant for returning goods, likelihood of buying again (or buying other products). In addition there are two differences among buyers which are pervasive and well recognized in economics:
>
> 1. The size of purchase, with large differences in costs of providing lots of different size.
> 2. The urgency of purchase, with possibly sufficient differences in elasticity of demand to invite price discrimination…
>
> A complete profit-maximizing price structure may have almost infinitely numerous price classes: the firms will have to decide upon the number of price classes in the light of the costs and returns from tailoring prices to the diversity of transactions.

134. As Stigler makes clear, a cartel in an industry where buyers are heterogeneous will face problems in setting and monitoring prices charged to the different buyers. This is especially true where buyers and sellers trade through privately-negotiated contracts containing both price terms and product specifications. Individually negotiated contracts can be difficult to monitor and manufacturers may be able to give hidden discounts by adjusting non-price contractual terms.

135. The TFT-LCD industry exhibits extensive buyer heterogeneity. Customers differ in their purchase volumes, bargaining power, and specification requirements. This results in price dispersion and makes price-fixing agreements more difficult to enforce. There is ample evidence in this case that Defendants negotiated individually with large buyers and

115 George J. Stigler (1964), "A Theory of Oligopoly," *Journal of Political Economy* 72(1) at 45-46.

charged different prices—including prices below those discussed at Crystal Meetings—to different customers.[116]

136. Differences in procurement processes across buyers provide one clear example of buyer heterogeneity in the TFT-LCD industry, amply illustrated by various DAP Plaintiffs. For example:

- Motorola's procurement process was rigorous and detailed. As one example, Motorola developed cost-based pricing models to aide in negotiations with TFT-LCD panel suppliers by analyzing subcomponent costs, materials costs and capital requirements at the supplier level.[117] As another example of its general (not necessarily TFT-LCD panel specific) procurement practices, Motorola employed various "price-masking" schemes, through which Motorola negotiated low prices from subcomponent manufacturers while hiding those prices from intermediate module suppliers. The subcomponent would then be sold to the module supplier at a higher price, preventing the module supplier from knowing the Motorola-brokered price.

- Nokia's procurement process involved specification of TFT-LCD panels designed specifically for Nokia handsets. Nokia's vendors then competed on quality and price, providing a mechanism for cheating, as under the Nokia procurement policy, each bidder would potentially gain substantial revenue and profit by undercutting its rivals.[118] In addition, as part of its procurement process, Nokia used a "should-cost" model to develop an understanding of the basis for its

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116 "Q: So there were no set prices for any panels at any time; you just individually negotiated the prices with everybody. Is that your – is that your position, sir? A: Based on what I recall, yes, things were done on an individual basis." (Deposition of Tadashi Yamada, Vol. I, March 12, 2009, 94:16-21.); "Most of the OEMs negotiate their volume requirements and pricing with LG Display on a monthly basis, and almost all customers negotiate prices at least every quarter." (Declaration of Yoong Ki Min, President of LG Display America, Inc., June 29, 2010, ¶29.) Prices were determined based on negotiations over a specific customer's specifications. (Deposition of Hiroyuki Morimitsu, March 13, 2009, 87:16-88:20.)

117 Centralized initiatives such as the Rapid Sourcing Initiative ("RSI") beginning in 2005 aimed to pull together cost-based pricing models in an organized way to cut supply chain costs. *See* Motorola RSI Playbook, MOTOLCD-00473604-665.

118 *See, e.g., Aho Depo.*, 88:15-89:4 and *Heikkila Depo.*, 48:24-49:17, Ex. 3977.

vendors' cost, with documents indicating this enabled Nokia to achieve "world record" prices and even prices below the should-cost model estimates.[119] Finally, Nokia also engaged in a form of price masking by negotiating component prices for TFT-LCD panels.[120]

- Dell's LCD panel procurement process is distinct in that it would purchase TFT-LCD panels that it then sold to system integrators. Dell would then purchase monitors from the system integrators. In order to sell the panels to the system integrator at the "market price," Dell would obtain panels from panel manufacturers at a discount off the market price.[121] Although this system does not mean that Dell necessarily avoided an alleged cartel overcharge, it could have facilitated cheating through the discounts Dell received in its TFT-LCD purchases.

J. POWERFUL BUYERS WITH SUBSTANTIAL KNOWLEDGE UNDERMINE A STABLE CARTEL BY CREATING INCENTIVES TO CHEAT, LIMITING DETECTION, AND DETERRING PUNISHMENT

137. An alleged cartel is less likely to succeed in reaching and maintaining elevated prices when selling to large, powerful buyers. Powerful buyers undermine a cartel agreement by facilitating cheating. In particular, when powerful buyers constitute a substantial portion of demand for any particular product, there is an enhanced incentive to cheat to serve those buyers, both because of the obvious immediate gains in revenue and

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119 Deposition of Rannikko, 131:11-132:1; *Heikkila Depo.*, 175:7-176:7. *See also* NOK000245236-70 at 38 and Deposition Ilkka Heikkila, September 29, 2011, Vol. II, 339:24-340:23 (explaining that "S-cost" refers to should-cost model).

120 *See, e.g., 30(b)(6) Aho Depo.*, 67:3-68:1, 230:21-231:9, Ex. 4216 indicating that Nokia negotiates by subcomponent, including subcomponent prices on TFT-LCD panels.

121 *See, e.g.,* 30(6)(b) Deposition of Troy Ignatowski, March 4, 2011,, 118:21-119:9 ("Q: And am I correct that Dell Global Procurement would mark up the panel price before it sold it to Lite-On [a system integrator]? A: Dell Global Procurement Malaysia would buy a price from the – the vendor. Q: Correct. A: And in this instance, the panel vendor. And then they would sell the price to Lite-On at whatever the market price detailed.")

also because a contract with a large buyer may provide the defecting firm with a steady source of revenue, lessening any concern over retaliation by other firms.[122]

138. In the case of TFT-LCD panels for monitors and notebooks, Table V-4 shows that Dell's share peaked in 2006 at 28.8 percent of Defendants' monitor sales and 22.7 percent of Defendants' notebook sales. As a buyer with a substantial share of demand for TFT-LCD panels for monitors and notebooks, Dell was in a position touse its leverage as a large buyer to negotiate a discount, and thereby facilitate cheating. Dell's ability to shift substantial volume between suppliers in turn generated substantial competition for its business.[123]

Table V-4: Dell Share of Defendant Sales of Monitor and Notebook TFT-LCD Panels

	Dell Share of Defendant Sales	
Year	**Monitor**	**Notebook**
2000		33.8%
2001	0.7%	22.4%
2002	5.0%	17.3%
2003	13.5%	18.6%
2004	20.2%	20.8%
2005	28.8%	21.5%
2006	29.5%	22.7%
2007	22.8%	19.3%
2008	22.0%	19.7%
2009	18.2%	16.4%

Source: Defendant transaction data.

139. One way that Dell exercised its power buying was to extract rebates from its suppliers based on the volume of TFT-LCD purchases. For example, Samsung agreed in 2001 to pay Dell a rebate of up to 3 percent if Dell met certain TFT-LCD purchase targets by fiscal year.[124] Similarly in May 2004, AUO agreed to reimburse Dell 1 percent

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122 *See, e.g.,* Motta (2004) at 145. ("Indeed, an unusually large order would give a very strong temptation to deviate: by deviating, a firm would make unusually large profits, and the perspective of losing collusive profits obtained under the typically small expected demand is not enough to deter the deviation.").

123 *See, e.g.,* Deposition of Edward Hung, June 14, 2010, 166:2-167:4. Samsung, LPL and AUO frequently lower prices to Dell to reduce inventory.

124 *See* DELL-00443517E.

of its TFT-LCD purchases.[125] In fact, Dell Expert Dr. Rao acknowledges that Dell received rebates on its purchases of TFT-LCD panels from AUO, LG, Samsung and Toshiba, estimating rebates from 1-4 percent, depending on the supplier and time period.[126] The use of rebates, rather than direct price reductions, facilitates cheating and undermines the alleged cartel by increasing the difficulty for vendors to observe rivals' price cuts. In this instance, variation in rebates across products and time periods makes discernment of the actual prices Dell paid for competitors' TFT-LCD panels particularly difficult.

K. THE ARGUMENTS ADVANCED BY PLAINTIFF EXPERT DR. CONNOR ARE INSUFFICIENT TO PROVIDE ANY ECONOMIC EVIDENCE ABOUT THE EFFECT OF THE ALLEGED CARTEL

140. Despite conducting no empirical analysis to assess the success of the alleged TFT-LCD cartel, Dell's Expert, Dr. Connor, concluded that he would not be surprised if the alleged cartel generated a significant overcharge at least periodically.[127] His conclusion is based on an attempt to draw an analogy between a "long and well-documented history of international cartels" and the alleged TFT-LCD cartel.[128] As such, Dr. Connor's expectation of a 20 – 25 percent overcharge is not based on an empirical analysis of the TFT-LCD industry. Instead, it represents his "meta-analysis" of estimated overcharges contained in published reports of other industries (his Exhibit 4 presents the histogram depicting the distribution of 770 median overcharges from published reports).[129]

125 *See* DELL-00443512E.

126 Rao Report, ¶¶136-140.

127 *Connor Report*, ¶142 ("I would not be surprised if the TFT-LCD cartel's overcharge was at least periodically at or above the 20% to 25% average observed for contemporary international cartels (Exhibit 4)").

128 *Connor Depo.*, 55:7-17.

129 The note on Exhibit 4 indicates that its source is a spreadsheet, dated August 3, 2005, and that it contains 770 "episodes." The figure in Exhibit 4 is reproduced from John M. Connor, "Price-Fixing Overcharges: Legal and Economic Evidence," *Research in Law and Economics,* 22 (2007), Figure 8. However, Dr. Connor did not provide the spreadsheet that generates Exhibit 4in his back up materials. Instead, he provided another spreadsheet that contains two sets of episodes - one with 741 episodes and another with 816 episodes – each of which provide the mean overcharges from published

141. My basic response to Dr. Connor's analysis is simple: Dr. Connor's approach is insufficient to provide economic evidence about the effect of the alleged TFT-LCD cartel. His analysis depicted in Exhibit 4 provides no basis for a conclusion relating to estimated overcharges in the TFT-LCD industry. Rather, Dr. Connor's conclusion of an expected 20 – 25 percent overcharge in the TFT-LCD industry is based on adjustments and a "back of the envelope calculation" for which he does not present any support or back up material.[130] Even if one were to accept that the average overcharge of a cartel is 25 percent, Connor's own work shows a large variation in overcharges across cartels. He provides no analysis why the average overcharge should apply to the alleged TFT-LCD cartel, particularly given all the hindrances to cartel success in the TFT-LCD industry.

142. It is, therefore, impossible to draw any meaningful conclusion from Dr. Connor's analysis regarding the overcharges arising from the alleged cartel in the TFT-LCD industry. The only way to determine whether there has been a significant overcharge from this alleged cartel is to examine the evidence in this industry, something Dr. Connor has not done.

143. I also note a number of specific flaws with Dr. Connor's analysis:

- First, the data include multiple observations for each alleged cartel, but Dr. Connor gives each observation equal weight. There are 279 unique cartels in the sample of 816 observations in Dr. Connor's back up data. For example, there are 26 observations related to the alleged cartel in lysine. Therefore, Dr. Connor apparently includes 26 observations for the lysine cartel in Exhibit 4.

- Second, Dr. Connor does not account for differences in how the overcharge is calculated across observations. For example, he admits that a number of overcharges are calculated assuming that absent the alleged cartel, price would equal marginal cost.[131] Such an assumption makes no economic sense in oligopoly markets or markets with differentiated products, and results in a

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reports. The data in this spreadsheet can be used to generate a similar, but not identical, histograms to the one presented in Exhibit 4.

130 *Connor Depo.*, 212:2-219:10.

131 *Connor Depo.*, 177:10-18.

substantial overstatement of the estimated overcharge when applied to such industries.

- Third, the largest overcharges in Dr. Connor's sample appear to have little or no relation to the present case. Dr. Connor testified that the largest estimated overcharges in his sample, some of which are from cartels that existed as far back as the 1600s, result when the cartel members form a virtual monopoly by splitting the market.[132] The overcharges among these observations in the sample are well over 50 percent and some are over 100 percent. Such figures pull up Dr. Connor's overall average overcharge despite having no bearing on the allegations in the TFT-LCD case.

VI. BASIC EMPIRICAL EVIDENCE ON TFT-LCD PRICES, QUANTITIES, AND CAPACITY UTILIZATION IS NOT CONSISTENT WITH CARTEL EFFECTS

144. The analysis to this point has established that neither the documentary record nor economic theory can determine whether the alleged cartel activities had a significant effect on TFT-LCD prices, particularly across all types of TFT-LCD panels sold to different buyers in different time periods. At most, the documentary record in this case can establish that some Defendants attempted to increase prices of some subset of TFT-LCD panels at particular points in time. And economic theory provides well-established reasons why these attempts may not have succeeded, particularly given the rapidly evolving production technology, the need to continue to invest in new fabs, the fact of highly differentiated (even customized) TFT-LCD panels, the steady stream of new panel types including entirely new applications, and the existence of more than a dozen producers and of powerful buyers.

145. The conclusion of the analysis in the previous sections is simple. Neither the documentary evidence in this case nor economic theory can establish that there were significant cartel overcharges. The question of whether and by how much the alleged cartel activities inflated TFT-LCD prices is ultimately an empirical one.

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132 *Connor Depo.*, 175:2-176:1.

146. In his report, Dr. Rao claims to find such empirical evidence for significant overcharges for on TFT-LCD panels—specifically notebook and monitor panels purchased by Dell (including panels incorporated in finished monitors)—from October 2001 through the end of 2004.[133]

In the remaining sections of this report, I refute Dr. Rao's evidence as follows:

- First, in this section, I show that the spikes or "humps" in large panel prices that are seen in the data—including in the 2001-2002 and 2003-2004 time ranges—are better explained by demand-side shocks than by activities of the alleged cartel. Hence, findings of positive overcharges prior to 2004 may be capturing these demand side shocks, as opposed to any cartel effects.

- Then, in Section VII, I show that Dr. Rao's claimed overcharges of nearly 26 percent (for Q4 2001 – Q4 2004) yield nonsensical results, including inexplicable changes in profit margins and sustained periods of negative economic profits in an industry requiring ongoing investments.

- Then in Section VIII, I show that Dr. Rao's overcharge findings are driven entirely by improperly eliminating 2005-2006 from his calculations;[134] arbitrarily dropping certain panels from calculations; and making other econometric errors.

- Finally, in Section IX, I show that a carefully constructed econometric model confirms the finding that overcharges are much smaller than those claimed by Dr. Rao.

A. PATTERNS OF PRICE AND QUANTITY CHANGES DURING THE ALLEGED CARTEL PERIOD ARE MORE CONSISTENT WITH DEMAND SHOCKS THAN WITH CONSPIRATORIAL RESTRICTIONS IN THE AMOUNT SUPPLIED

147. If one is looking for evidence of conspiratorial price increases in the pre-2007 (or pre-2005, as Dr. Rao claims) time period, one natural question may be whether observed "price humps"— in which the decline in panel prices slowed from trend and even reversed and moved upward (see Figure II-20)—reflect successful cartel efforts. In this

133 *Rao Report*, ¶ 6.

134 *See Dell Complaint,* ¶96 where Dell alleges that the conspiracy continued into December 2006.

section, I demonstrate that the price humps appear to correspond to demand shocks, rather than to any activities of the alleged cartel.

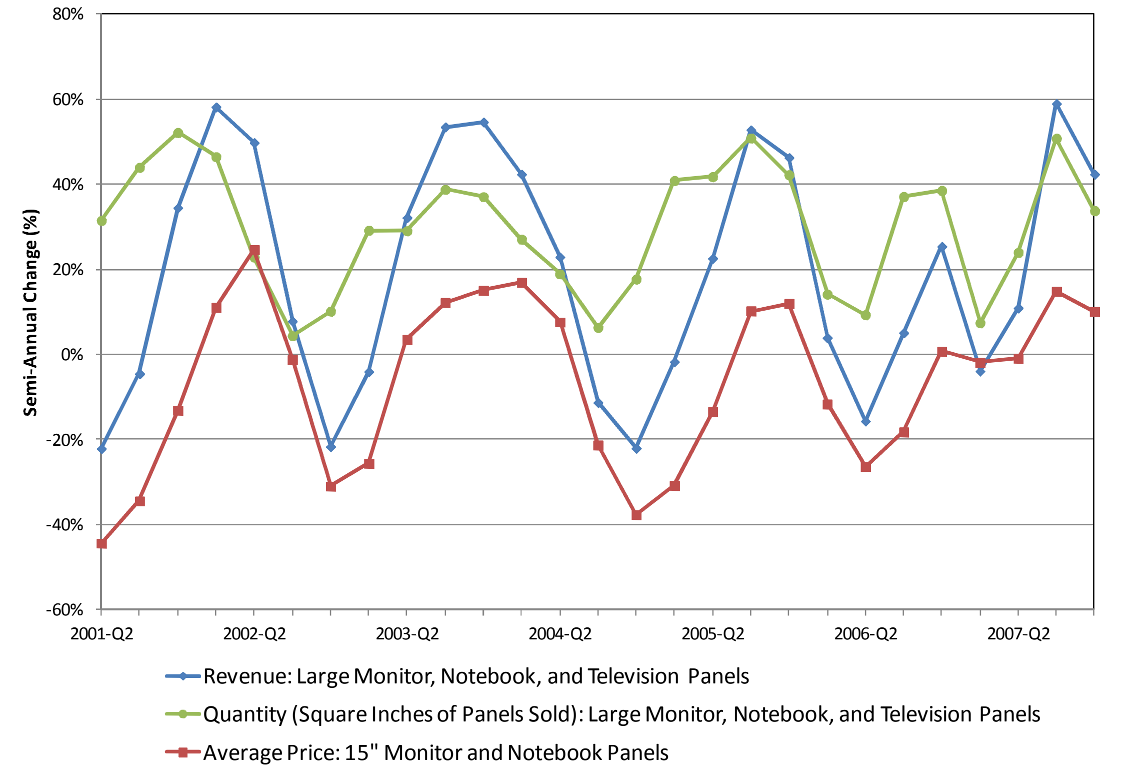
148. As a matter of economics, a conspiratorial price increase is an example of a supply-driven price change. That is, a conspiratorial price increase is equivalent to a reduction in the amount supplied, which causes the industry to move up the (downward sloping) demand curve to a lower quantity/higher price combination. Put simply, if the conspiracy raises prices, buyers will purchase less (but this will still be profitable due to higher margins). So, all else equal, if periods of rising prices are driven by conspiratorial effects, one would expect them to be associated with lower quantities—or more precisely, growth rates in quantities that are below the overall trend line—indicating price effects driven by a reduction in output.

149. Demand-driven price increases, on the other hand, are associated with increases in industry-wide output, all else equal.

150. Hence, a natural question is: Are observed periods with higher-than-average price growth associated with lower-than-average quantity growth (suggesting output restriction, including possible conspiratorial effects) or higher-than-average quantity growth (suggesting non-conspiratorial, demand side effects)? In this section, I show that observed periods of higher than average price growth are also associated with higher than average quantity growth, pointing to demand side explanations for the price humps, rather than actions of the alleged cartel.

151. Figure VI-1 compares the changes in quantity and total revenue for all panels 10" in diagonal and larger to changes in the average price of the high-selling 15" monitor and notebook panels. The periods of above average price increases are clearly associated with periods of above-average growth in industry output and revenue for large panels. Hence, this straightforward review of pricing and quantity trends indicates that the "price humps" are more consistent with positive demand shocks that push up both price and quantity than with any conspiratorial restriction on the amount supplied.

Figure VI-1: Changes in Average Prices of 15" Monitor and Notebook Panels vs. Changes in Quantity and Revenue of Large Panels



Source: DisplaySearch panels data, DISP_LCD_000001; Defendants' transaction data

B. PATTERNS OF PRICE CHANGES AND CAPACITY UTILIZATION DURING THE ALLEGED CARTEL PERIOD ARE MORE CONSISTENT WITH DEMAND SHOCKS THAN WITH CONSPIRATORIAL RESTRICTIONS IN THE AMOUNT SUPPLIED

152. Plaintiffs have also alleged that the alleged cartel sought to reduce capacity utilization in order to reduce supply of TFT-LCD panels and drive up prices.[135] However, an alternative, non-conspiratorial explanation for any observed variations in capacity utilization is that fluctuations in demand for TFT-LCD panels (as part of the crystal cycle) led to variations in capacity utilization.

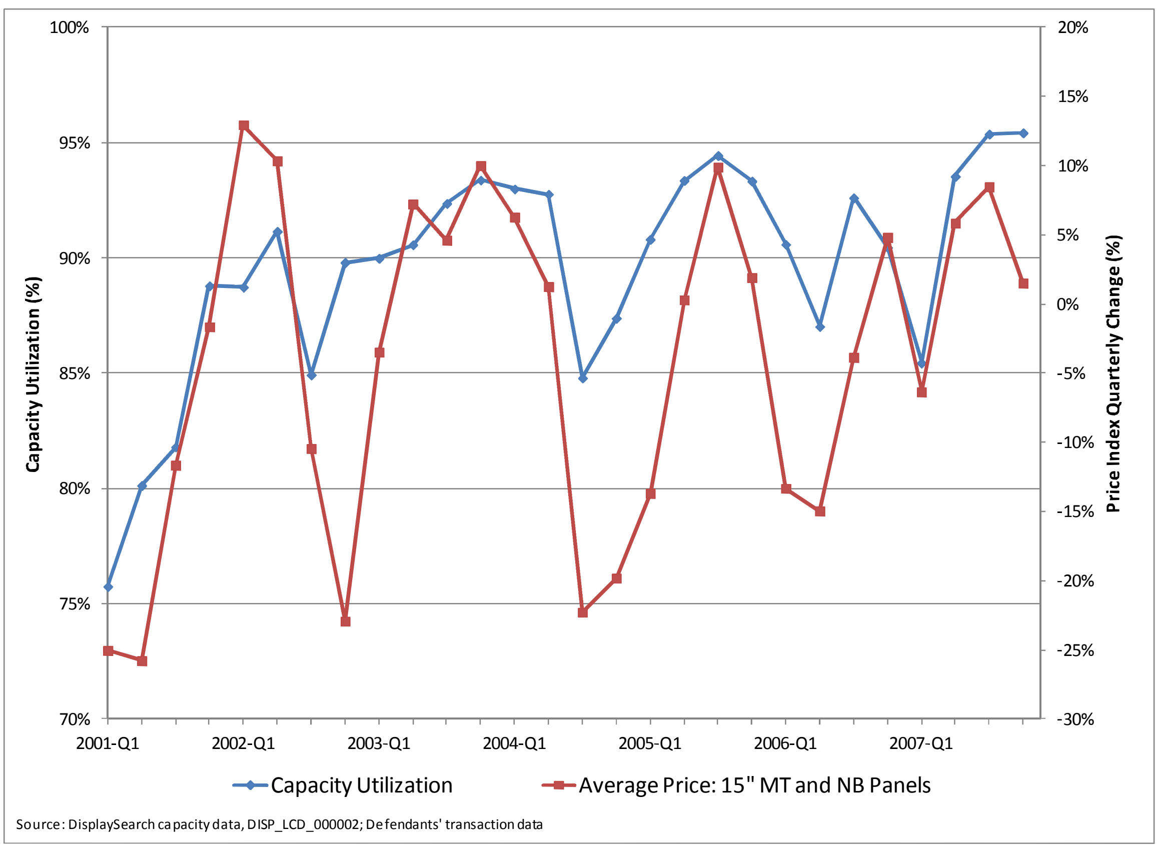
153. As with the relationship between changes in quantity and changes in price, these two explanations for variations in capacity utilization (output restrictions from the alleged cartel versus demand-driven changes) have distinct implications for the relationship between capacity utilization and prices. Under the Plaintiff's theory, all else equal,

[135] See *Rao Report*, ¶51.

periods of low capacity utilization should be associated with higher prices (slower rates of price decline). Under a demand-driven explanation, periods of low capacity utilization should be associated with lower prices (faster rates of price decline).

154. Figure VI-2 plots the percentage changes in average price of the high-selling 15" monitor and notebook panels vs. capacity utilization. It is clear from the figure that capacity utilization was generally quite high throughout the alleged conspiracy period. And the dips in capacity utilization tend to be associated with periods of rapidly declining prices, not periods of rising prices. By way of example, the dips in capacity utilization in late 2002, late 2004, and early 2006 are accompanied by rapidly declining prices. Hence, the data are more consistent with demand-driven price fluctuations than with the notion that conspiracy-induced reductions in capacity utilization drove prices higher.

Figure VI-2: Changes in Average Prices of 15" Monitor and Notebook Panels vs. Capacity Utilization



155. Finally, I note that the fact that capacity utilization tends to be high in the periods of increasing prices provides another explanation—quite distinct from any alleged cartel effects—for the price increases. It is well accepted that periods of high capacity

utilization tend to be associated with higher costs, as plants are run beyond optimal levels, resources are generally stretched, and yields slip.[136] Hence, the increase (or at least slowed decline) in prices at these times may be due to inflated costs due to high capacity utilization levels. In fact, this explanation has been advanced by industry observers.[137]

VII. THE FLAWS IN DR. RAO'S OVERCHARGE ESTIMATES ARE REVEALED IN THEIR IMPLAUSIBLE IMPLICATIONS REGARDING DEFENDANT PROFITS

156. Dr. Rao claims that the overcharges on monitor and notebook panels purchased by Dell were nearly 26% between Q4 2001 – Q4 2004.[138] An overcharge at this level is simply implausible for at least two reasons:

- First, such an overcharge level implies that price-cost margins also would have been much lower prior to the end of Dr. Rao's alleged damages period (end of 2004) than after. Dr. Rao has provided no explanation for why a but-for world without a conspiracy would have exhibited such a jump in margins after 2004.

- Second, even when using highly conservative measures of the Defendants' capital costs, the overcharges asserted by Dr. Rao imply that most or all of the defendants on which I have data would have earned *negative economic profits* over the alleged cartel period. Such a result (and thus the overcharge estimate that generates it) is not reasonable. It implies a competitive equilibrium in the industry in which firms earn consistently negative economic profits, a situation that would not be consistent with the substantial and ongoing capacity investments observed in this industry during the class period, as documented above.

136 *See e.g.,* Peter S. Yoo, "Capacity Utilization and Prices Within Industries," *Federal Reserve Bank of St. Louis Review*, 77(5) at 15. ("When firms attempt to produce beyond their 'normal' levels, the costs of producing the additional output becomes increasingly expensive if the firm's production process exhibits diminishing returns-to-scale. The higher cost then translates into higher prices.").

137 John A. Matthews (2005), "Strategy and the Crystal Cycle," *California Management Review,* 47(2) at 17.

138 *Rao Report*, ¶6.

157. All of these calculations are based, in whole or in part, on Defendants' accounting cost data. It is well known that accounting cost data are at best imperfect measures of true economic costs.[139] Hence, I design the analyses in this section to be informative even given the weaknesses in accounting cost data: (i) by pointing to the jump in but-for margins implied by Dr. Rao, for which there is no explanation regardless of how costs are measured, and (ii) by using a range of highly conservative assumptions on the treatment of the cost of capital and depreciation to show that my conclusions on economic profits are robust.

A. THE OVERCHARGES PROPOSED BY DR. RAO IMPLY A BUT-FOR WORLD IN WHICH PRICES ARE BELOW REPORTED COSTS DURING THE ALLEGED CARTEL PERIOD, BUT ABOVE REPORTED COSTS AFTER THE ALLEGED CARTEL PERIOD

158. Some Defendants in the various TFT-LCD price fixing cases have provided cost data.[140] For these Defendants, I calculate the average price per unit, the average cost per unit, and the average but-for price per unit implied by Dr. Rao's overcharges.

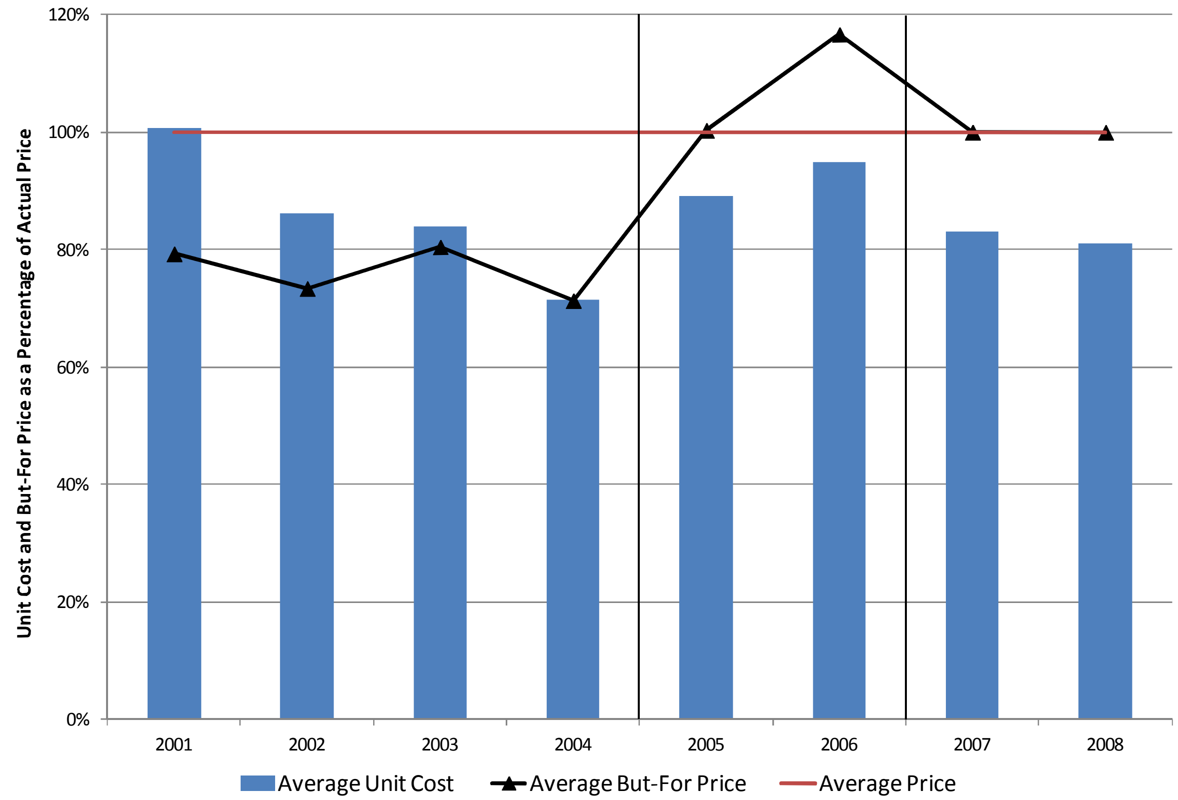
159. As discussed in more detail in Section VIII, below, Dr. Rao estimates an average overcharge of 25.8 percent for October 2001 through 2004, with no overcharge after that.[141] Figure VII-1 shows both the but-for prices implied by Dr. Rao's overcharge estimates and unit costs as percentages of actual prices (for monitor and notebook panels).

139 I have previously testified to the limitations from using accounting data to estimate profit margin. *See Carlton IPP Report*, ¶181 and *Carlton Depo*., 281:6-19, 284:17-285:15. I also discuss these limitations in my textbook. *See* Carlton and Perloff (2005), Chapter 8.

140 Defendants AUO, CMO, HANNSTAR, LGD, SAMSUNG and TOSHIBA (TMD) have provided measures of cost of goods sold.

141 *Rao Report*, ¶6.

Figure VII-1: Dr. Rao's But-For Price vs. Unit Costs (as a Percentage of Actual Price) – Monitor and Notebook Panels



Source: Defendants' transaction and cost data; Plaintiffs Experts' overcharges.
Note: 2001 includes only data for October-December.

160. As seen in the figure, Dr. Rao's overcharges imply a but-for world in which prices are substantially below reported costs for October 2001 through 2004 but then substantially surpass reported costs after 2004. For the 2001-2004 period, Dr. Rao's but-for prices are up to 15 percent *below* reported costs. But after 2004, but-for prices are between 13 percent and 23 percent *above* reported costs.[142] Dr. Rao does not provide any reasonable explanation for this implied sharp shift in margins as of the end of 2004. And I am not aware of any change in the Defendants' cost methodology that would explain this dramatic change in price-cost margins. Rather, this result indicates that the large overcharges estimated by Dr. Rao are unreasonable.

142 Indeed, Dr. Rao's but-for prices would indicate that the largest price-cost margin occurred in 2008, in the midst of a world-wide recession.

B. ECONOMIC PROFIT MARGIN CALCULATIONS ALSO CONFIRM THAT, UNDER A BROAD RANGE OF ASSUMPTIONS, DEFENDANTS WOULD HAVE EARNED SUBSTANTIALLY NEGATIVE ECONOMIC PROFITS IN THE BUT-FOR WORLD PROPOSED BY DR. RAO

161. In this section, I estimate the but-for economic profits (price minus economic cost) taking into account accumulated investments, cost of capital, and plant depreciation.[143] I find that the overcharge estimates proposed by Dr. Rao yield the implausible result of *substantially negative* economic profits for most or all of the Defendants (on which I have data)—as well as all Defendants on average—throughout the alleged conspiracy period.

162. To undertake this analysis, I follow methodologies used in the literature to estimate economic profit margins with the data available in this case. In particular, I use a definition of economic profits that accounts for the cost of capital, as regularly used in the literature.[144] I include data for 2002-2004 for the seven Defendants with financial

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143 For simplicity, the calculations in this section hold quantity sold constant. Of course, lowering price would likely lead to more quantity sold. However, given that overall capacity utilization was around 90 percent in most time periods (*see* Figure VI-2), the amount of output that could have been added without investing in additional facilities (and thus substantially increasing capital costs, at least partially offsetting any profit gained) is limited.

144 An estimate of economic profit can be obtained from accounting data as the net operating profit after taxes (NOPAT), minus the cost of the capital employed. This includes the after-tax profit generated by the company's core operation, excluding gains from non-operating assets and interest payments. In addition, economic profits take into account a cost not included in accounting statements: the cost of the capital the company has raised from investors. The cost of capital is estimated as a hurdle rate or weighted average cost of capital (WACC), multiplied by the capital employed (calculated as the average total assets during the year, minus current liabilities). (*See* G. Bennett Stewart, III (1991), *The Quest for Value: EVA Management Guide*, HarperCollins Publishers, Inc., Chapter 3; Richard A. Brealey, Stewart C. Myers, and Franklin Allen (2011), *Principles of Corporate Finance*, 10th ed., McGraw-Hill Irwin, Chapters 12 and 28; and Tim Koller, Marc Goedhart, and David Wessels (2010), *Valuation: Measuring and Managing the Value of Companies*, 5th ed., McKinsey & Company, Chapters 6-7.) When estimating but-for economic profits, I add back the corporate income taxes that Defendants would not have to pay if they had lower revenues. To do this, I use the top corporate tax rates for each Defendant's country. (*See* data from Economist Intelligence Unit.)

statements available for the business segment that includes the TFT-LCD manufacturing division.[145]

163. Because it can be difficult to estimate economic profit margins, I use a broad range of assumptions for the most critical parameters, namely, the rate of return on capital, capital employed, and depreciation.[146] To be conservative (by using a low estimate of the cost of capital), I consider a base case using a rate of return on capital (*i.e.*, a weighted average cost of capital (WACC)) of 6 percent. Six percent is below any WACC calculated by Bloomberg for any Defendant in the 2000-2006 period, as shown by Plaintiff Expert Mr. Stowell.[147] I also consider several (conservative) alternative versions, including an extreme case in which there is no cost of capital (WACC equals zero). Additionally, I consider a more conservative assumption on the amount of capital employed by each firm, as well as slower rates of depreciation.[148]

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145 In some cases, only partial data were available for the business segment that includes the TFT-LCD manufacturing division. In these cases, I used pro-rata calculations based on the consolidated financial statements (which include other company divisions). This affected calculations of depreciation, taxes, interest payments, and current liabilities. In addition, for LGD and Sharp, I could not obtain financial statements with sufficient information for every year.

146 For ease of exposition, I compute economic profits by dividing economic profits by net sales (total sales minus discounts and returns).

147 *Stowell Report*, Table 10. Mr. Stowell stated in deposition that he had no reason to believe these WACCs were inaccurate. (*Stowell Depo.*, 232:10-24.) In a previous report, I present third-party estimates of Defendants' WACCs of between 6.2 percent and 14 percent (*See Carlton IPP Sur-Reply Report*, Table III-7).

148 In terms of the amount of capital employed, I measure assets and current liabilities as the minimum of their values at the beginning and end of the year (rather than the average for the year). Since Defendants made substantial investments during the class period, this measure tends to use the capital employed from the beginning of the year, which can be significantly lower than the average for the year, reducing the estimated cost of capital. For depreciation rates, the sensitivity analysis assumes that assets depreciate at half the rate used in the accounting statements. This reduces the cost of sales and increases the profit margin.

Table VII-1: Average After-Tax Profit Margin after Deducting Dr. Rao's Overcharge (2002-2004)

Defendant	Base Case (6% Cost of Capital)	0% Cost of Capital	Minimum Capital Employed	Half Depreciation Expense
AUO	-13.2%	-5.2%	-12.1%	-6.5%
CMO	-17.3%	-6.5%	-15.2%	-9.6%
HannStar	-31.8%	-18.5%	-29.8%	-24.5%
LGD	-5.1%	0.9%	-3.3%	0.1%
Hitachi*	-23.5%	-19.8%	-23.1%	-23.1%
Sharp*	-17.8%	-13.9%	-17.7%	-15.4%
Toshiba/TMD*	-18.9%	-14.9%	-18.9%	-17.2%
Average	***-16.7%***	***-9.8%***	***-15.6%***	***-12.4%***

Notes: Based on financial statements for LCD division, where available. Assumes no change in quantity. Averages weighted by annual sales from DisplaySearch panel data.
* LCD division data based on division income statements with prorated data from consolidated financial statements on depreciation, taxes, interest expense, and current liabilities.

164. Based on Dr. Rao's estimated overcharge of 25.8 percent for October 2001 through 2004, Table VII-1 shows that, in my base case, Defendants would have an average economic loss of around 17 percent of sales in the but-for world.[149] Even assuming a 0 percent cost of capital, Defendants would have an average loss of 10 percent. In other words, no matter what is assumed about the cost of capital, Dr. Rao's overcharges imply that, but-for the alleged cartel, the Defendants would have earned substantially negative economic profits over the entire 2001Q4-2004Q4 period, an implausible result.

C. A BUT-FOR WORLD IN WHICH ECONOMIC PROFITS WERE NEGATIVE YET DEFENDANTS CONTINUED TO MAKE SUBSTANTIAL INVESTMENTS IN NEW FABS IS NONSENSICAL

165. One way to understand why a but-for price that yields a negative economic profit margin is unreasonable is to consider the fact that the Defendants made substantial investment in new fabs during the alleged conspiracy period. As a matter of fundamental economics, firms will not continue to invest capital in an industry that generates negative economic returns. Hence, there is no reasonable economic equilibrium in which prices would have been reduced by as much as that implied by Dr. Rao's overcharge estimates, yet firms would have continued to make the investments that were observed during the

149 *Rao Report*, ¶6. Table VII-1 assumes that the overcharge Dr. Rao estimates for monitor and notebook panels applies to the entire company.

alleged conspiracy period. Dr. Rao's implicit assumption that one could hold all else fixed and simply reduce prices by the amount of their estimated overcharges is not reasonable. The negative economic profits would have led to reduced investment in new, efficient fabs—and perhaps exit from the industry—which would have put *upward pressure* on prices, a fact that Dr. Rao's model simply ignores.[150]

VIII. DR. RAO'S ESTIMATE OF A 25.8 PERCENT PANEL OVERCHARGE IS BASED ON FAULTY ECONOMETRIC METHODS AND A FAILURE TO INCLUDE ALL RELEVANT DATA

166. Dr. Rao claims to have developed an econometric model that yields overcharges on monitor and notebook panels purchased by Dell of nearly 26% between Q4 2001 and Q4 2004. In this section, I explain that Dr. Rao's claimed overcharges are driven entirely by his failure to consider all relevant time period and panels, as well as his use of unreliable econometric methods.

A. DESCRIPTION OF DR. RAO'S OVERCHARGE METHODOLOGY

167. Dr. Rao estimates overcharges using an econometric "backcast" technique.[151] Using data on Dell purchase orders, Dr. Rao estimates a regression model only using data starting after his alleged conspiracy period, from the first quarter of 2007 through the first quarter of 2011.[152] He then uses the estimates from this model to predict but-for prices (*i.e.*, he backcasts) for the period 2001Q4 – 2004Q4[153] (Dr. Rao's alleged damages period). Dr. Rao's overcharges are based on the difference between the actual prices paid for a given panel in a given quarter and his predicted but-for price for that panel-quarter.[154]

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150 Indeed, Plaintiff Expert Professor Bernheim appears to agree with me. He indicates that one needs to consider whether the price levels implied by the econometric analyses are consistent with the levels of investment required to satisfy demand at those prices. (*Bernheim Report,* ¶139.)

151 *Rao Report,* ¶106.

152 *Rao Report,* ¶97.

153 *Rao Report,* ¶111.

154 *Rao Report,* ¶106.

168. The data used for Dr. Rao's model contains prices, costs and forecasted and actual shipment data (from DisplaySearch) for several different panels (defined as a unique application-size-resolution combination) across quarters. To build this dataset, Dr. Rao starts with a dataset of individual records of panel purchases by Dell from 2001 to 2011.[155] Dr. Rao aggregates these data to the application-size-resolution-quarter level, leaving him with a dataset of 27 different application-size-resolution combinations and 300 application-size-resolution-quarter observations in his post-conspiracy period.[156] Dr. Rao then merges these data with cost and shipment (forecasted and actual) data from DisplaySearch at the application-size-resolution-quarter level.[157] Because not all panels are present in both the Dell price dataset and the DisplaySearch dataset, merging the two datasets leaves Dr. Rao with 25 unique panel combinations, and 275 panel-quarter observations in his post-conspiracy period.[158]

169. Dr. Rao's model predicts the natural logarithm of panel prices based on the following variables:[159]

- Log of costs of that panel, from the quarter prior to the invoice date for each panel sale, as published by DisplaySearch
- Log of the previous quarter's "demand shock," defined as "the ratio of actual demand as calculated by DisplaySearch in a quarter to quarterly demand as forecasted by DisplaySearch four quarters earlier."[160] Although Dr. Rao refers to this variable as a "demand shock," it is actually just the ratio of actual to forecasted sales volume (across all large panel applications). Dr. Rao provides no support for his interpretation that observed sales above or below forecasted sales are due to a demand shock rather than a supply shock.

155 *Rao Report,* ¶98.

156 *IBID.*

157 *Rao Report,* ¶¶100-102, n. 126, Tab 22.

158 Rao Report, Tab 22.

159 *Rao Report,* ¶¶97-104.

160 *Rao Report,* ¶102.

Finally, Dr. Rao includes fixed effects (indicator variables) for each application-size-resolution combination in his data and allows for first order autocorrelation in his error terms.[161]

170. Using this specification, Dr. Rao estimates his model on the single stacked dataset, using all 275 observations from all 25 application-size-resolution combinations for the period 2007Q1 – 2011Q1. With these estimates, for any panel that appears in both the post-2007 period and the alleged damages period, one could (and indeed Dr. Rao's computer programs do) predict a but-for price for each panel in each quarter in Dr. Rao's alleged damages period (2001Q4-2004Q4) to compute an implied overcharge for each panel-quarter combination.

171. However, instead of relying on the predictions from his regression model for all panel-quarter combinations where it is feasible to do so, Dr. Rao's reported overcharge percentage relies on estimates only for panels that have "at least 8 observations in the post-conspiracy time period."[162] As a result, Dr. Rao uses the estimated overcharge percentage from his regression model for *only four of the 17* panels present in his damages period.[163] For the other 13 panels, Dr. Rao simply assigns the overcharge percentages in any given quarter using the unweighted average in that quarter of the estimated overcharge percentage on the original four panels for which he does estimate overcharge percentages using the regression model (or a subset of the four for which Dr. Rao has price data for that quarter).

172. Among other flaws I discuss below, it is worth noting here that Dr. Rao provides no explanation for why he apparently believes that his regression model produces reliable estimates only for those panels observed for more than eight post-conspiracy quarters, nor any indication of how he determined that the required number of post-

161 *Rao Report,* ¶¶103, and Dr. Rao's Work Papers. Dr. Rao implements this estimation approach using the XTREGAR command in STATA (http://www.stata.com/help.cgi?xtregar (February 15, 2012), *site visited* February 15, 2012).

162 *Rao Report,* ¶99.

163 *Rao Report,* ¶99. *See also* Tab 34. There are only 17 panels that Dell purchased between 2001Q4 and 2004Q4, although it bought other panels in later years, which is why Dr. Rao's regression dataset actually contains data for 25 different panels.

conspiracy quarters for such reliability is eight rather than, say, twelve. He also provides no indication why it is more reliable to use estimated overcharge percentages for *other panels* rather than rely on a panel's own regression-based overcharge estimates, even if the estimate is based on a regression dataset that has less than eight quarters of data *for that specific panel*.[164]

173. Dr. Rao then computes the overall overcharges for any given quarter (or longer time period) using a revenue weighted average of the overcharges computed for each panel-quarter combination, using Dell's purchase revenues as weights. With this technique, Dr. Rao calculates overcharges of approximately 25.8 percent for the period 2001Q4-2004Q4.[165]

174. In the remainder of this section, I explain why Dr. Rao's finding of a large overcharge is not reliable. First, I explain some fundamental flaws in his overall methodology. Second, I note that Dr. Rao's own model, when applied through the end of Plaintiffs' alleged damages period (December 2006), yields very small overcharges. Third, I show that extending Dr. Rao's dataset in a way that allows me to compute overcharge estimates using a larger, more representative set of panels (even when using Dr. Rao's rules for which panels are included when computing overcharges), yields substantially *negative* overcharge estimates, even when making no other changes to Dr. Rao's methodology. Finally, I show that making other reasonable changes to Dr. Rao's specification also reduce his overcharge estimates, in some cases making them quite negative. *My conclusion from the extreme sensitivity of Dr. Rao's results to these changes is that his model simply cannot provide any support for a conclusion of large overcharges on Dell's TFT-LCD panel purchases.*

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[164] To be clear, Dr. Rao's regression dataset has 275 total observations across 25 panels. But Dr. Rao does not use the regression model to generate overcharge estimates for panels that make up less than eight of those 275 observations. Note that, other than the panel specific fixed effects, all of the parameters of Dr. Rao's regression model are based on all of the 275 observations, not panel-specific observations. So, although he does not say so explicitly, Dr. Rao must believe that the panel-specific fixed effect is not reliably estimated with less than eight observations. I know of no basis for this cutoff and Dr. Rao certainly does not provide one.

[165] Dr. Rao runs sensitivity analyses, trying slightly different specifications for his model for the period 2001Q4-2004Q4, resulting in overcharges ranging from 24.8 percent to 37.6 percent. (*Rao Report*, ¶¶ 113-119.)

B. DR. RAO'S MODEL HAS FUNDAMENTAL WEAKNESSES THAT RENDER IT INCAPABLE OF GENERATING RELIABLE OVERCHARGE ESTIMATES

175. Before turning to the sensitivity of Dr. Rao's model to minor, reasonable changes, I outline the fundamental flaws with this model that render it incapable of providing reliable support for a claim of large overcharges. I focus on three such flaws.

176. First, by relying on a backcast technique, Dr. Rao is forced to use data only from after 2006 (and only on those panels for which he can measure all necessary variables) to draw inferences about what panel prices *would have been but for the alleged cartel* prior to 2007, going as far back as 2001. As such, his assumption is that the actual price patterns after 2006 can inform one what prices would have looked like many years earlier in the absence of the alleged cartel. Yet, as developed in more detail below, Dr. Rao struggles to find panels on which he has even eight quarters of data with which to estimate these post-2006 price patterns. Consequently, Dr. Rao's estimated overcharge percentages are based on a set of panels that were not even purchased (in any meaningful volume) by Dell in 2001-2002 and only in limited volumes in 2003.

177. In addition, as developed in Section II and Section VIII above, the post 2006 period was quite different from the years just after 2000, with a major global recession that likely depressed prices and a shift in monitor technology starting in 2003 that saw LCDs nearly completely replacing the previously dominant CRT screens. Dr. Rao's regression model does not account for either of these changes. Therefore, rather than representing cartel effects, it is likely that some or all of the price differences between Dr. Rao's predicted prices and actual prices arises from both the differing mix of panels in the post 2006 period (relative to Dr. Rao's alleged damages period) and from changes in marketplace conditions for which Dr. Rao's model does not control fully. Dr. Rao certainly provides no basis to demonstrate that he is measuring cartel effects rather than other changes in the industry.[166]

178. Finally, Dr. Rao's "demand shock" variable likely not only affects prices but also *is affected by* price changes deriving from other sources, meaning that it is an

166 *See Hausman Report,* ¶31 for further discussion of the fact that structural changes in the TFT-LCD industry render backcast or "prediction" models invalid in this context.

"endogenous" variable and including it as a control variable (without accounting for this endogeneity in estimation, as Dr. Rao does not) leads to biased and inconsistent parameter estimates and thus invalid overcharge predictions.[167] In particular, as described above, the demand shock is simply the ratio of actual sales volume for large LCD panels to the forecasted sales value from four (or in some runs seven) quarters earlier. Dr. Rao interprets this as a demand shock which may affect prices. But suppose prices rise for some other unexpected reason, such as an unobserved capacity outage at a large plant, a change in competitive conditions, or a cost shock that is not fully captured by Dr. Rao's cost variable. Such a price spike is likely to push sales below forecasted levels, creating a "reverse causality" problem, in which case the variable Dr. Rao interprets as a measure of a demand shock (that raises prices) actually reflects a shift in supply conditions that raises price thereby lowering the amount demanded. In effect, Dr. Rao is including a function of quantity sold on the right hand side of a regression designed to study price; this is the classic economic example of endogeneity, a condition that is known to lead to biased and inconsistent parameter estimates rendering Dr. Rao's but-for price predictions based on these parameters invalid.[168]

C. A VALID OVERCHARGE ESTIMATE CANNOT DROP ESTIMATED OVERCHARGES FOR 2005-2006. INCLUDING THESE YEARS, DR. RAO'S OWN MODEL YIELDS OVERCHARGES OF ONLY ONE PERCENT

179. Dell's complaint in this matter claims that defendants conspired to raise prices on TFT-LCD panels "at least as early as January 1, 1996 and continuing thereafter up to and including December 11, 2006 *at a minimum*" [emphasis added].[169] Moreover, Dell claims that many defendants attended meetings and had bilateral discussions "between at least 2001 and 2006."[170] Based on the complaint, then, damage calculations should include the period through December 2006.

167 *See* Peter Kennedy (2003), *A Guide to Econometrics* Fifth Edition, Blackwell Publishing at 180.

168 *See Hausman Report,* ¶[31, indicating that if there are endogenous variables and appropriate econometric techniques are not used, "estimates will be biased and inconsistent, and thus unreliable."

169 *Dell Complaint*, ¶96.

170 *Dell Complaint,* ¶¶118-122.

180. However, Dr. Rao bases his overcharge calculations only on sales during 2001-2004, excluding 2005 and 2006 from his results. Using precisely the same method as Dr. Rao uses, but simply applying it to the 2005-2006 period, Dr. Rao's model actually estimates large negative overcharges (i.e., that but-for-prices would have been higher than actual prices) during the 2005-2006 period. As a result, *the average overcharge implied by Dr. Rao's model when correctly applied to the full 2001Q4-2006Q4 period is only 1 percent, far below the 25.8 percent that Dr. Rao reports.*

181. Dr. Rao provides no reasonable basis to exclude 2005-2006 from his calculations. In an attempt to justify this exclusion, Dr. Rao claims that the model fits better in the 2001Q4-2004Q4 period than in the 2005-2006 period. It is not clear what Dr. Rao means by this claim; by its very nature a backcast model expects there to be a gap between predicted and actual prices and uses this gap as a measure of effects from the alleged cartel. To the extent that Dr. Rao is saying the gaps between predicted and actual prices in 2005-2006 are too large to be credible, he is admitting that his model is unreliable. In addition, Table VIII-1 shows that for each of the four panels on which Dr. Rao computes overcharges, the coefficient of variation is lower for the 2005-2006 period than for the period 2001Q4-2004Q4, meaning that his predictions are closer for 2005-2006 than for the earlier years.[171] This is not surprising; a model fit with data starting in 2007 will likely yield better predictions on the more recent 2005-2006 time period than the earlier 2000Q4 – 2004Q4 period.

Table VIII-1: Fit of Rao Preferred model 2001Q4-2004Q4, 2005-2006

	Coefficient of Variation	
Panel	**2001-2004**	**2005-2006**
M17SXGA	24.4%	13.8%
M19SXGA	35.4%	12.0%
N154WXGA	26.1%	15.6%
N17WXGA+	18.6%	11.5%

Source: Rao work papers, panel_ochg.do, toappend.dta.

171 The coefficient of variation, as used here, is defined as the square root of the mean squared prediction error divided by the mean value of the dependent variable (price).

182. Indeed, Dr. Rao's own logic further explains why the 2005-2006 period needs to be included in overcharge calculations. In particular, to explain why the alleged cartel might have led Dell to pay *lower* prices during 2005-2006 than it would have paid in the absence of the alleged cartel, Dr. Rao posits that, in order to find a post-cartel price equilibrium—Defendants might "undershoot" the competitive price for some period of time.[172] Hence, by Dr. Rao's own logic, Dell may have paid less for TFT-LCD panels in 2005-2006 than it would have absent the alleged conspiracy. As such, an accurate assessment of the full effect of the alleged cartel on prices paid during Plaintiffs alleged conspiracy period must include these negative overcharges in the 2005-2006 time periods.

183. In fact, in his deposition, Dr. Rao claims to have netted out any negative overcharges from any positive overcharges to come up with an overall overcharge estimate.[173] This is false. The only periods for which Dr. Rao estimated negative overcharges were in 2005-2006, and he drops these from his overcharge calculation rather than netting them out.

184. Both economic theory and basic statistics explain why it is entirely possible to obtain negative overcharge estimates in certain time periods and why these negative values must be included to compute overall overcharge estimates. For example, the economic theory of cartels explains that, when cartels enter price wars, members may actually charge prices *below the competitive level* for at least some period of time.[174] And basic statistics indicates that any measure of overcharges contains some inherent error, such that the estimated overcharge may be negative in certain time periods, even if the

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172 *Rao Depo.*, 136:14-137:6 "A: But, obviously, if you are moving from a collusive world to a world where there is less collusion, you are not exactly going to find that price right away, whatever that competitive price is. So you could undershoot, and then, at some point, the new market equilibrium goes from one that's a collusive equilibrium to a competitive equilibrium, but that path could have one where the prices are going under. Q: Right. And so the best -- the best interpretation of your model, I take it, is that in 2002 -- from 2005 to 2006, the actual prices were actually below the prices that would have existed absent the conspiracy? A: With respect to Dell -- Q: Yes. A: -- the actual prices are below what my model is estimating as the but-for price during those two years."

173 *Rao Depo.,* 263:18-23.

174 Andreu Mas-Colell, Michael Whinston, and Jerry Green (1995), *Microeconomic Theory*, Oxford University Press at 420-421.

alleged cartel's effect on prices was actually positive in that time period.[175] In either case, simply dropping the negative values will lead to a biased (upward) estimate of the overall overcharge, just as one would obtain a biased downward estimate if one chose simply to omit certain positive values. The appropriate procedure to arrive at an overall measure of the cartel's effect is to average in all the values. When I use this procedure on Dr. Rao's model—changing nothing else about his approach—I obtain an overcharge estimate of only one percent.

D. EXTENDING DR. RAO'S DATASET TO MAKE IT MORE REPRESENTATIVE, BUT OTHERWISE LEAVING HIS APPROACH UNCHANGED, DR. RAO'S MODEL PRODUCES CONSISTENTLY NEGATIVE OVERCHARGES

1. Dr. Rao's overcharge calculations are based on a small, unrepresentative set of panels

185. As stated above, Dr. Rao imposes a rule that only panels for which he has at least eight quarters of post-cartel period data can be used in his overcharge percentage calculations. As a result, only four of the 17 individual application-size-resolution combinations (products) present in Dr. Rao's dataset during his damages period are used to calculate overcharge percentages.

186. Dr. Rao presents no justification for his eight quarter rule, nor do I know of one. And the rule leads to a highly non-representative sample of panels on which overcharge percentages are estimated. For example, for the years 2001-2002, there were essentially no purchases of any of the four panels Dr. Rao uses to compute the overcharge percentages.[176] So Dr. Rao is computing Dell's overcharge percentage in these years on the basis of panels Dell did not even buy in any meaningful quantities.[177] For 2003, these

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175 In claiming that he nets out negative values in determining overcharges, Dr. Rao acknowledges that negative values can occur due to "stochastic" errors inherent in statistical models. *Rao Depo.,* 263: 18-23. "So anytime I see something that's a negative just like I see a positive, I realize in both instances there's obviously some variation that's purely because of the stochastic nature of the model."

176 The15.4" WXGA notebook panel that Dr. Rao uses to estimate overcharges represents 0.004 percent of Dell's purchases by revenue in 2002, and Dell made no purchases during 2001-2002 of the other three panels used to predict overcharges.

177 The Dell purchase data that Dr. Rao uses to determine volume of commerce for his damages calculation shows no sales of 17"SXGA & 19"SXGA monitor panels to Dell

four panels make up only ten percent of Dell's purchases. At the same time, Dr. Rao's rule omits from his overcharge percentages the 14.1"XGA notebook panel—the panel for which Dell had the largest purchase volume during 2001-2004 and which made up 56.5 percent, 42.0 percent, and 32.6 percent of Dell's purchases in 2001-2003, respectively.

187. The four panels that Dr. Rao uses in calculating his overcharge percentage also appear to be unrepresentative of the excluded panels. For example, prices for the four panels that Dr. Rao used in his overcharge percentage calculation declined substantially faster during Dr. Rao's alleged damages period than price for the 13 panels he did not use. For example, Table VIII-2 compares the percentage price decline from 2001Q4 – 2004Q4 for two panels that Dr. Rao included in his overcharge percentage calculations vs. three panels that he did not include in his overcharge percentage calculation.[178] Notably, prices for Dr. Rao's included panels declined by more than 30 percentage points more than the excluded 14.1" XGA Notebook panel and by more than 15 percentage points more than each of the 15" XGA panels.

Table VIII-2: Price Declines for Panels Purchased by Dell, 2001Q4 - 2004Q4

Group	Panel	Percent Decline
Excluded Panels	14.1 XGA Notebook	16.8%
	15 XGA Monitor	34.8%
	15 XGA Notebook	35.3%
Included Panels	17 SXGA Monitor	52.0%
	19 SXGA Monitor	50.5%

Source: DisplaySearch.

until 2003Q4. In order to even have actual prices to use to compute overcharges for these panels, Dr. Rao must use price data from DisplaySearch rather than from Dell.

178 The panels selected are those that have data in the estimation period *and* which have data back to 2001Q4.

2. Dr. Rao has presented a methodology for extending his sample to additional panels.

188. In fact, Dr. Rao has already used and endorsed a method for extending his price series to aid in his modeling. In particular, he uses DisplaySearch data to extend the prices of the 17"SXGA and 19"SXGA Monitors back in time—prior to when they were purchased by Dell—to enable him to determine actual panel prices and thus overcharges for these panels back to 2001Q4.[179]

189. Using this same technique—using DisplaySearch prices for panel-quarters with no Dell prices—also allows me to extend prices for several panels farther forward into Dr. Rao's clean period.[180] In particular, I am able to extend the 14.1"XGA notebook and 15"XGA notebook and monitor panels forward into the estimation period, such that I have at least eight observations in the estimation period for each, sufficient to use them in computing overcharge percentages, even under Dr. Rao's own arbitrary rules.[181] In this way, I am able to base the calculation of an overcharge percentage on seven panels, rather than the four used by Dr. Rao.[182] This yields a much more representative sample than used by Dr. Rao of Dell purchases for use in computing overcharges, as seen in

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[179] *Rao Report*, Data Appendix ¶30.

[180] The fact that Dr. Rao uses these DisplaySearch prices as actual panel prices in his overcharge calculations means that he must believe they are equivalent to prices paid by Dell, at least on average. Otherwise they would lead to incorrect overcharge estimates. As long as he is correct, then they are also valid to use as the dependent variable in a regression analysis (meaning they will not generate bias or inconsistency in parameter estimates) since any gap between the DisplaySearch price and the Dell price for a given panel-quarter will simply enter the regression's error term.

[181] I compared the Dell prices versus the DisplaySearch prices for all seven panels that are extended. In all cases but one, the panels for which I extend the Dell price series with DisplaySearch prices, the DisplaySearch prices are within 10 percent of Dell prices, a better ratio than Dr. Rao's achieves with his extension of the 17"SXGA panel, where Dell prices are 13 percent higher than the DisplaySearch prices in the last quarter of overlap between the price series. The one case where this is not true is the 15"XGA monitor panel, where Dell prices are 33 percent larger than DisplaySearch prices. However, excluding the 15"XGA monitor panel actually decreases overcharges, so I have been conservative by leaving it in.

[182] In addition, I have augmented Dr. Rao's cost data with updated DisplaySearch cost data.

Table VIII-3, below, which lists, for each year from 2001-2006, the percentage of Dell purchase dollars made up by the four panels Dr. Rao uses versus the seven panels I use.[183]

Table VIII-3: Dell Purchase Volume Captured by Dr. Rao's Prediction

Year	Dr. Rao's Four Panels	Expanded 7 Panels
2001	0.0%	59.9%
2002	0.0%	46.6%
2003	10.4%	56.1%
2004	51.0%	78.0%
2005	65.3%	82.9%
2006	67.4%	75.4%
Average Through 2004	**15.4%**	**60.1%**
Average Through 2006	**32.3%**	**66.5%**

Source: Rao work papers.

3. Using Dr. Rao's methodology on the more complete set of panels shows *negative* overcharges for both 2001Q4 – 2004Q4 and 2001-2006

190. Table VIII-4, below compares estimates using Dr. Rao's original approach (using four panels to compute overcharge percentages) versus my approach that uses both additional data in estimation and seven panels to compute overcharge percentages. Notably, using the additional data and the larger sample of panels—but making no other changes to Dr. Rao's model–yields overcharge estimates of *negative* 6.2 percent for 2001-2004 and *negative* 9.5 percent for 2001-2006. Given that extending the data to better represent the products that Dell actually bought during Dr. Rao's alleged conspiracy period yields negative overcharges, Dr. Rao's model cannot support an inference of large positive overcharges.[184] Dr. Rao's method of including only those

183 There is no way to capture 100 percent of Dell's purchase dollars in the prediction, as some products purchased by Dell in the period 2001Q4-2004Q4 are simply not purchased at all after 2006 and are therefore not represented in Dr. Rao's estimation.

184 Alternatively, I could use the set of panels that Dr. Rao used in estimation but relax his arbitrary rule for the number of post-cartel period quarters required for a panel to be used in computing overcharge percentages. Including all seven panels in the overcharge

panels with at least eight quarters of data in the post-cartel period is responsible for his high overcharge estimates.

Table VIII-4: Comparison of Rao Model Results

Data	Overcharges		
	Through 2004	2005 -2006	Through 2006
Rao Original[1]	25.8%	-9.3%	1.0%
DS Extended[2]	-6.2%	-10.8%	-9.5%

Source: Rao Sensitivities.do

[1] 1Q Lag Costs & 1Q 4Q Demand Shock

[2] DS Extended uses DisplaySearch data to extend price series for 14.1"XGA Notebook, 15"XGA Notebook and Monitor, and 17" WXGA+ Notebook.

E. Other reasonable changes to Dr. Rao's model substantially reduce his overcharge estimate, demonstrating his model's lack of reliability

191. In this section I demonstrate that, even when using Dr. Rao's original dataset, other reasonable changes to his model substantially reduces his overcharge estimates, making them consistently negative for 2001-2006 and often negative for 2001-2004. The fact that Dr. Rao's model cannot even maintain predictions of positive overcharge estimates given small, reasonable changes indicates that it cannot support an inference of large positive overcharges.

192. First, I replace the once-lagged cost variable that Dr. Rao uses with the current cost associated with the panel, as of the date of the invoice. Dr. Rao argues that the once-lagged cost (*i.e.,* cost from one quarter prior to the invoice date) should be used because prices are negotiated well before the invoice date.[185] However, as a matter of economics, regardless of when negotiations occur, the relevant costs for price setting are the costs expected to hold as of the time of sale (as those represent the costs associated with replacing the panel that is being sold.). These expected costs at time of sale are certainly

estimate, using Dr. Rao's original data, results in average overcharges of 1.9 percent for 2001-2004 and *negative* 8.7 percent for 2001-2006.

185 *Rao Report,* ¶ 100.

not the costs that hold at the time of negotiations and, to the extent that firms form unbiased expectations of future costs, the expected costs at time of sale are likely best captured by the actual costs at the time of sale.[186]

193. In any case, using current costs provides a good test of the sensitivity of Dr. Rao's findings. As seen in the second row of Table VIII-5, making this single change causes Dr. Rao's overcharge estimate for 2001-2004 to fall from 25.8 percent to 14.0 percent. For the appropriately specified 2001-2006 damages period, overcharges fall from 1.0 percent to *negative* 8.3 percent.

Table VIII-5: Dr. Rao Preferred Model Sensitivities

No.	Changes to Rao Specification	Overcharges		
		Through 2004	2005 -2006	Through 2006
[1]	Base Model[1]	25.8%	-9.3%	1.0%
[2]	Current Costs	14.0%	-17.5%	-8.3%
[3]	Current Costs + Quantity Weights	-9.7%	-38.3%	-29.9%

Source: Rao Sensitivities.do
[1]Rao original specification, 1Q Lag Costs & 1Q 4Q Demand Shock.

194. Another common way to test the robustness of regression results is to see how much estimates change if the regression is "weighted," meaning estimated in a way that puts more weight on observations that are more important in some sense. As one example, one can weight each observation (panel-quarter) by the number of units of that panel sold over the estimation period (often referred to as quantity weighting.). It is well

186 Either the current or lagged cost variables may suffer from a measurement error problem if it does not capture perfectly the cost used by manufacturers and Dell in negotiating prices. The results above do not attempt to resolve this problem, but rather simply to show the sensitivity of Dr. Rao's result to use of an alternative, and likely more relevant, cost control.

established that a well-specified model should not yield substantially different results when run weighted vs. unweighted.[187]

195. Dr. Rao's results are highly sensitive to weighting. For example, re-running the model in row 2 of Table VIII-5 (with current costs), but simply weighting the observations by quantity reduces estimated overcharges to *negative* 9.7 percent for 2001-2004 and to *negative* 29.9 percent for 2001-2006.[188]

196. Hence, even using Dr. Rao's own dataset, two slight variations on his control variables—both of which make economic sense and improve the fit of the model—reduce his estimated overcharges to 14.1 percent for 2001-2004 and *negative* 8.8 percent for 2001-2006. If I also weight the observations, so that panel-quarters representing greater quantities sold receive more weight, his estimated overcharges become substantially negative for either time period.

197. In sum, Dr. Rao's model simply cannot support an inference of large positive overcharges to Dell from the alleged cartel.

IX. A CAREFULLY CONSTRUCTED ECONOMETRIC OVERCHARGE MODEL CONFIRMS BASIC EMPIRICAL PATTERNS AND FINDS SMALL, STATISTICALLY INSIGNIFICANT OVERCHARGES

198. In this section, I present my own econometric model of overcharges in the TFT-LCD industry, as an alternative to the flawed model presented by Dr. Rao. In so doing, I appropriately treat the alleged cartel period as running through 2006—as alleged in Plaintiffs' Complaint—rather than only through 2004 as Dr. Rao does.

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187 Jerry A. Hausman (1978), "Specification Tests in Econometrics," Econometrica at 46. *See also* Halbert White (1982), "Maximum Likelihood Estimation of Misspecified Models," *Econometrica*, 50(1) at 12-13.

188 Quantity weighting Dr. Rao's base model reduces overcharges from 25.8 percent to 18.0 percent for 2001-2004 and from 1.0 percent to *negative* 7.1 percent for 2001-2006. Using revenue weights as opposed to quantity weights produces very similar results. Revenue weighting Dr. Rao's original specification produces overcharges of 17.9 percent for 2001-2004 and *negative* 7.3 percent for 2001-2006; revenue weighting the specification that uses current costs results in overcharges of *negative* 6.6 percent for 2001-2004 and *negative* 27.3 percent for 2001-2006.

A. PRICE-COST MARGINS BEFORE AND AFTER THE END OF 2006 REVEAL NO EVIDENCE OF CARTEL EFFECTS

199. Before turning to a complex econometric model, it is good practice to look at the basic patterns in the data that underlie such a model.

200. A straightforward way to examine whether what the data reveal about the alleged cartel's effect on prices is to examine price-cost margins before and after the end of the alleged cartel. Among the most basic predictions of the economic theory of cartels is that a successful cartel should generate higher price-cost margins than would otherwise occur. One would therefore expect, all else equal, that the price-cost margin during the alleged conspiracy would be significantly higher than after 2006. In this section, I show that there is *no* evidence that the alleged TFT-LCD cartel had such an effect.

201. Measuring margins can be difficult as data for cost measures that correspond to economic marginal costs are rarely available.[189] The current case is no exception. Defendants have provided measures of cost of goods sold, but these measures are admittedly imperfect measures of the marginal economic costs that economic theory says are the basis for pricing decisions. Nevertheless, these are costs that the Defendants maintain in the ordinary course of business, and there is no reason that I am aware of to think the Defendants' treatment of these costs, and thus the relationship between these costs and the true marginal economic costs, has changed after the end of the alleged cartel.

202. Figure IX-1 through Figure IX-4 plot quarterly margins from 2005-2008 by application, with margins calculated as total revenue divided by total cost of goods sold across all defendants for which I have data on sales and costs for the given application in the quarter.[190] The figures certainly show no systematic pattern of lower margins following the end of the alleged cartel. If anything, monitor and notebook panel margins (the two applications for which there is by far the most evidence of discussions at the

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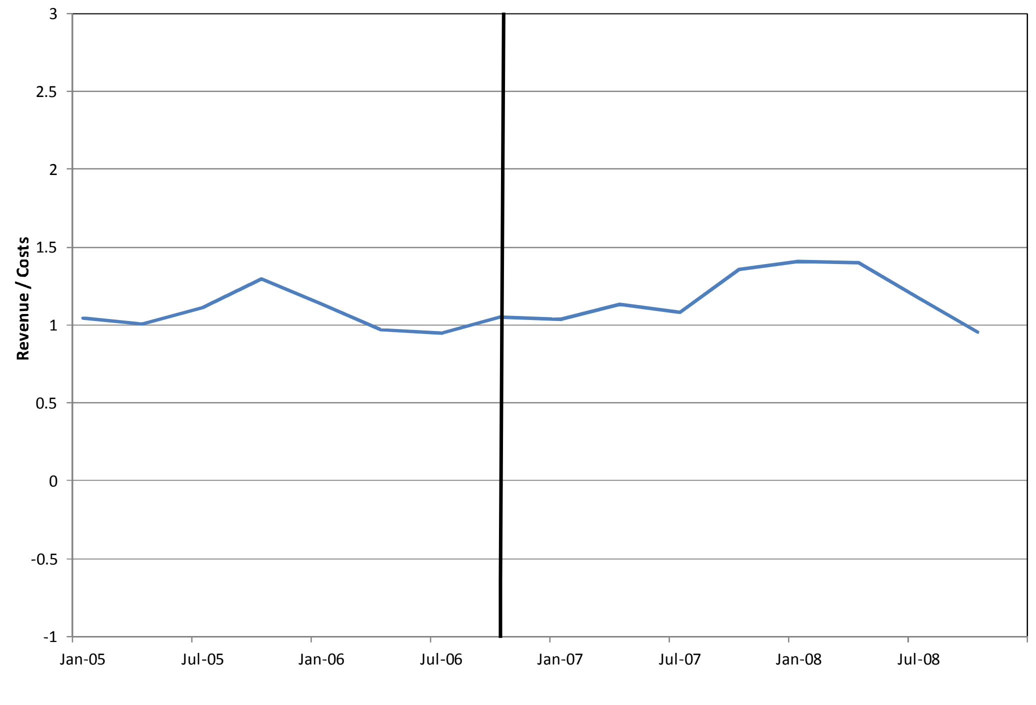
189 I have previously testified to the limitations from using accounting data to estimate profit margin. *See Carlton IPP Report,* ¶181 and *Carlton Depo.*, 281:6-19, 284:17-285:15. I also discuss these limitations in my textbook. *See* Carlton and Perloff (2005), Chapter 8.

190 Defendants AUO, CMO, HANNSTAR, LGD, SAMSUNG and TOSHIBA (TMD) have provided measures of cost of goods sold.

Crystal Meetings) appear to increase slightly after the end of 2006. TV panel margins are slightly more volatile, but if anything they also look higher after 2006 than before. Mobile phone margins show no break as of the end of 2006 and generally are quite flat throughout the 2005-2008 time period.

Figure IX-1: Average Price / Cost for Notebook Panels



Source: Defendants' sales data.

Figure IX-2: Average Price / Cost for Monitor Panels

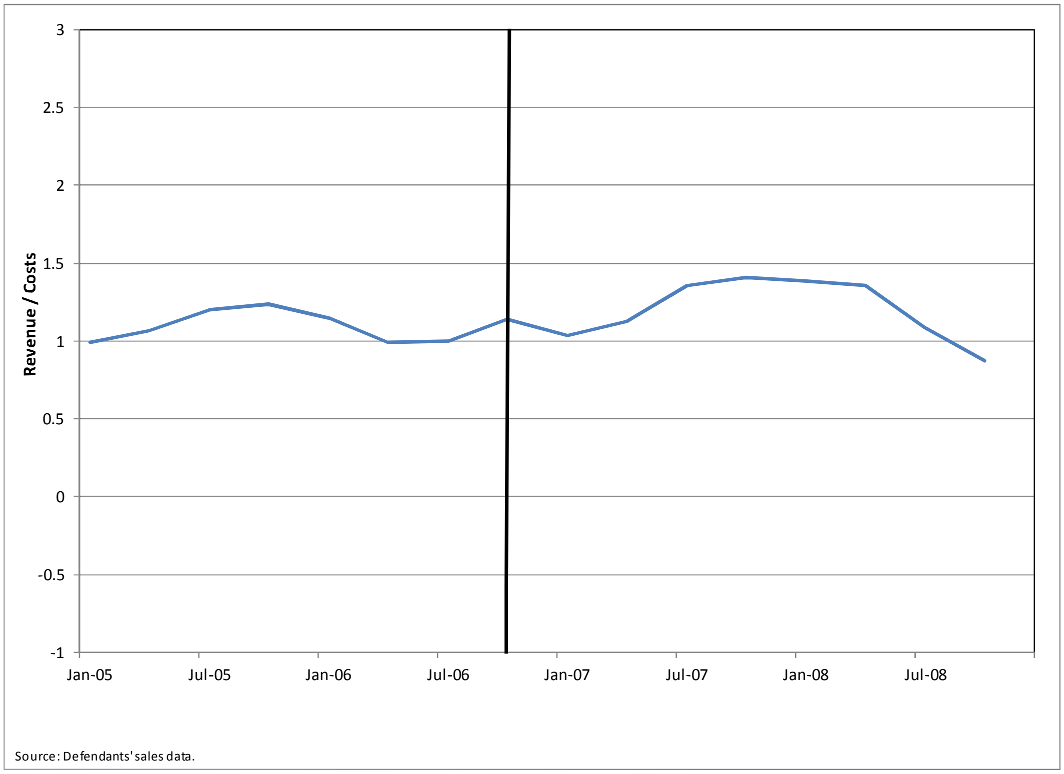


Figure IX-3: Average Price / Cost for TV Panels

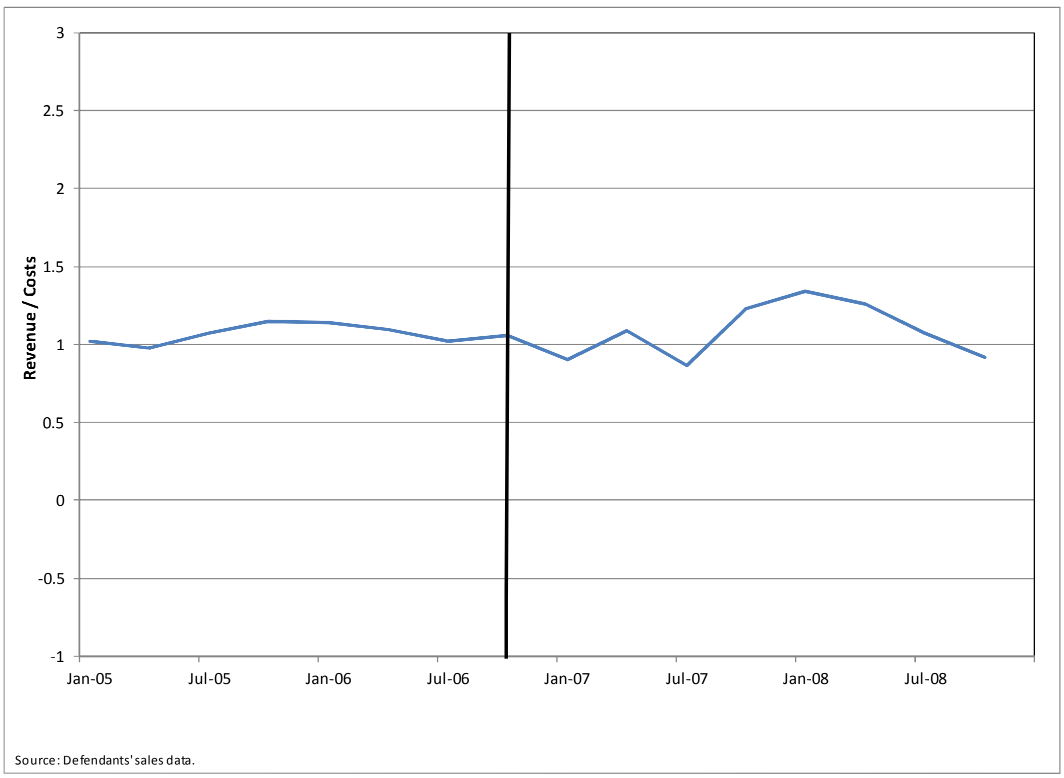
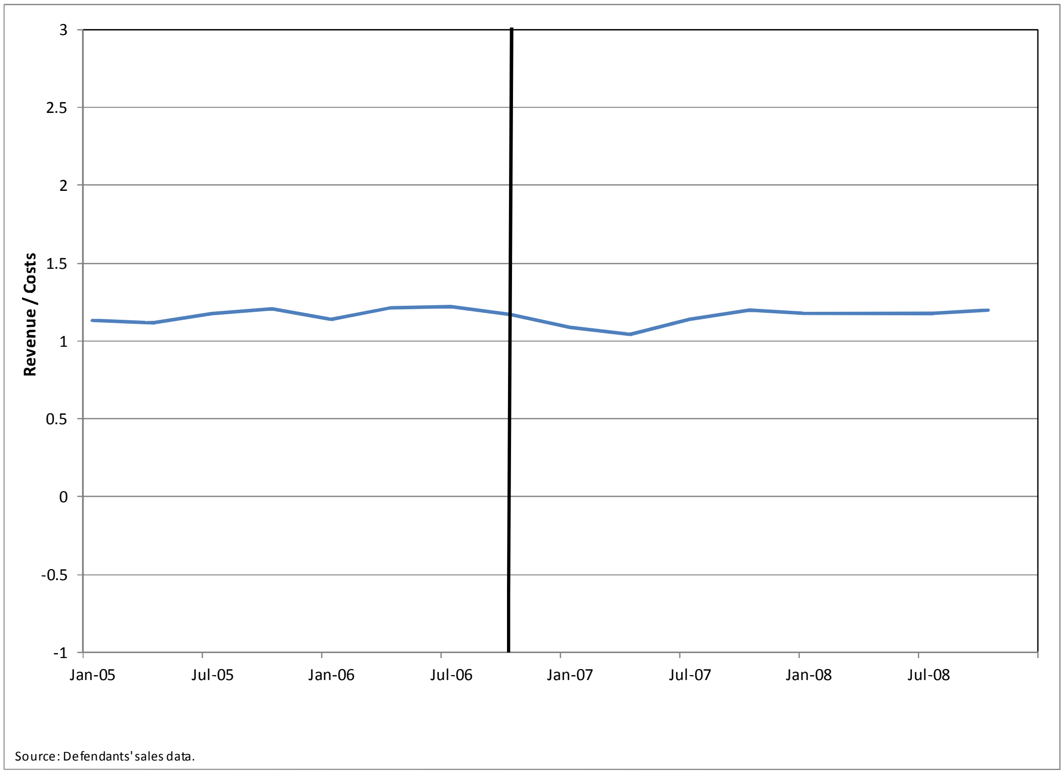


Figure IX-4: Average Price / Cost Mobile Panels



203. Table IX-1 provides a summary of these margin data, computing the ratio of total revenues to total costs for the two years before (2005-2006) and after (2007-2008) the end of the alleged cartel. Again, there is no systematic pattern of higher margins during the alleged cartel period. Monitor and notebook panels have margins that are higher *after* the end of the alleged cartel. For TV and mobile panels, average margins are nearly identical before and after the end of the alleged cartel. Summing across all the products, average margins actually *increased* after the end of the alleged cartel, from 1.09 to 1.17.[191]

191 Performing this Price / Cost analysis in this section on the full 2001-2008 time period produces very similar results, thus supporting my conclusions.

Table IX-1: Average Price / Cost for Alleged Conspiracy Period & Post Period

Application	Period	Total Revenue	Total Cost	Revenue / Costs
Mobile	2005-2006	2,573,624,298	2,187,112,098	1.18
	2007-2008	2,640,432,487	2,292,449,762	1.15
Monitor	2005-2006	18,353,136,798	16,722,625,665	1.10
	2007-2008	23,015,042,040	18,745,544,004	1.23
Notebook	2005-2006	9,648,819,860	9,041,280,565	1.07
	2007-2008	17,549,122,990	14,537,271,579	1.21
TV	2005-2006	11,495,929,870	10,753,013,692	1.07
	2007-2008	19,905,020,200	18,501,287,967	1.08
Total	2005-2006	42,071,510,825	38,704,032,020	1.09
	2007-2008	63,109,617,717	54,076,553,312	1.17

Source: Defendants' transactions data.

B. OVERVIEW AND LIMITATIONS TO ECONOMETRIC EVIDENCE

204. The incremental value of going beyond these clear patterns in the price-cost margin data to a more complex econometric study is fairly limited for at least two reasons. First, having already demonstrated that price-cost margins fluctuated within a reasonably stable range during and after the alleged cartel—and certainly were not systematically higher during the alleged cartel—I have already used the available data to control for the cost of production, the most obvious control variable to incorporate in an econometric study.

205. To undo the conclusion of no large overcharges (based on the stable price-cost margins), Plaintiff Experts would need to point to some specific economic factors to explain why, in the but-for world, margins should have been substantially *lower* during the alleged cartel period than after. My review of Plaintiff Expert reports finds no such clear explanation, and I see no obvious candidate explanations. Resorting to the complexities of an econometric model is no substitute for clear explanations.

206. Of course, additional study—including study based upon an econometric model of price—can confirm (or refute) the evidence that I have already presented so I proceed to attempt to estimate an econometric model of the TFT-LCD industry, just as have the numerous Plaintiff Experts.

207. However, as I explain more fully below, my second reason for believing that such a study is likely of limited value comes from my understanding of the nature of the TFT-LCD industry and of econometric modeling.[192] I have described an industry undergoing very large changes over time in terms of technology, products, and major suppliers. I have reservations about the feasibility of constructing a reliable econometric model of this industry that I can estimate with the available data and that controls for relevant economic factors. I can estimate such an econometric model only if it is sensible either to estimate a model using data from the alleged cartel period and non-cartel period, using as assumption that the estimated relationships involving the non cartel variables would apply during the alleged cartel period absent the cartel, or alternatively that it is sensible to estimate a model using data from some benchmark period and then assume that the estimated model applies to the alleged cartel period. As I explain more fully below, neither assumption is necessarily warranted in this industry given its history and given the limited data availability in the possible benchmark period. Rather than accept such assumptions, I require that my econometric models pass some tests to make sure that I am not making unwarranted assumptions. For some of the TFT-LCD panel applications, I am unable to construct a model that passes my tests for reliability and stability.

208. Despite my reservations about the feasibility of constructing a reliable econometric model of price determination for TFT-LCD panels, I attempt to do so. For those applications where a reliable model can be built, reasonable specifications of such a model confirm the basic patterns presented thus far, demonstrating a lack of significant overcharges from the alleged cartel.

209. I am careful to build an econometric model that reflects an understanding of the key TFT-LCD industry conditions developed through the report thus far, including the need for disaggregated analysis by category of TFT-LCD panel (or by application within those categories) and the allowance for the evolution of prices over time. To verify that the model is reasonable, I make sure the estimated economic relationships generally

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192 My prior experience showing how unreliable Plaintiff Experts' econometric models have been, in both the Class proceedings and in this proceeding, has also shaped my views. *See Carlton DPP Report, Carlton IPP Report, Carlton DPP Sur-Reply Report,* and *Carlton IPP Sur-Reply Report.*

comport with economic theory. I also require that any specific model I rely on exhibit stable economic relationships over time, as absent that stability condition, there is too much risk of confounding cartel effects with all the other changes in the industry. I also verify that the model meets certain guidelines that reasonable econometric models in this industry should meet, outlined below with reference to the guidelines laid out by Dr. Jerry Hausman in his report in this matter.[193]

210. In the remainder of this section, I detail my econometric model and results. Based on these results, I reach the following conclusions:

- When it is possible to construct a reliable model, I rely on what are called dummy variable models to estimate possible cartel effects rather than a prediction model estimated over a short period of time. A prediction model is likely to be less reliable than the dummy variable model for this industry given the enormous changes in the industry and short time period of the non-cartel period.[194]

- Models of notebook or mobile phone panel prices pass a test for model stability over time, so I am able to rely on them for my econometric analysis. Models of all small panels, TV panels, and monitor panels do not pass such tests for model stability (on any time periods I have studied) and thus are not reliable to estimate a cartel effect.

- None of my preferred econometric models finds a statistically significant effect of the alleged cartel on prices. Hence, consistent with the facts of the industry and the basic patterns in the data, to the extent there was an overcharge, it is too small to be distinguished statistically from random price fluctuations. Put simply, one cannot conclude from my model that a successful cartel (which had any statistically significant effect on prices) existed.

- To the extent that I am asked to assume the existence of a successful cartel and use my model to form the best available prediction of its effect on prices, my

193 *Hausman Report,* ¶31.

194 *See Hausman Report,* ¶31. In other situations with fewer changes in the marketplace and ample data in the non-cartel period, the prediction model can be an appropriate and preferred method to use to estimate a cartel effect.

model yields an overcharge prediction of approximately 0.4 percent for notebook computers and 1.9 percent for mobile phones.

- To the extent that I am asked to provide an estimated overcharge for other small panels, monitors, or televisions, my main response is that available econometric evidence does not allow me to provide a separate overcharge estimate for those products. However, I consider the estimate for notebook computers to be the best available proxy from my econometric models for other large panels (monitor and television panels), although a likely upper bound for reasons discussed below. I consider the estimate for mobile phones to be the best available proxy based from my econometric models for other small panels, although a likely upper bound for reasons discussed below.

211. The remainder of this section proceeds as follows. In part B, I discuss the challenges an econometric model of TFT-LCD prices and alleged cartel effects must overcome and some minimal standards for meeting those challenges. In part C, I provide the basic details of the model that I build in accordance with those standards. In part D, I provide some details on estimation of the model (full details are available in my backup materials). In part E, I present the basic results from my models, including the stability results that limit the set of applications for which reliable overcharge estimates can be formed, coefficient estimates that comport with basic economic theory, and other statistical tests supporting the reliability of my model. In part F, I discuss the implied overcharges from my model, including the fact that they are not statistically significant. In part G, I present some results to demonstrate the robustness of my findings to reasonable changes in my model.

C. Standards for Selecting an Appropriate Econometric Model, Including Model Stability

1. The need for a stable, structural model

212. The purpose of an econometric model in a price fixing matter is to determine the price increase *caused* by the cartel, not simply a price change that coincides with the cartel but is caused by other factors. For example, a price increase could be caused either by a cartel or by an increase in costs. An econometric model can allow an analyst to

distinguish the two effects. This means that any econometric model must be carefully constructed to be sure that one is actually measuring price changes that are caused by the cartel and not misattributing price changes arising from other changes in the economic environment to the cartel.

213. I construct an economic model that relates the prices of panels to measures of the economic environment that can affect prices—particularly measures of cost and demand. To do this successfully, I need to know that the underlying economic pricing relations, which my model uncovers, are stable between the alleged cartel period and the non-cartel period, so that any differences in prices between these two periods can reasonably be attributed to the causal effects of the cartel. This means that any model that is used to assess causal impacts of the cartel is based on the assumption that there is structural stability of the model across the non-cartel period and the alleged cartel period. If the model is not structurally stable, then I cannot use it to measure the causal effects of the cartel.

214. As explained by Dr. Hausman in his report on this matter, when listing appropriate econometric methods for use in examining overcharges in this case:[195]

> A model based on the underlying economic structure of the industry should be used. A model which does not specify the economic structure correctly is unlikely to be stable over time and will not predict damages accurately. This consideration becomes especially important because 2008, in the "post-cartel" period, was affected by the severe recession which affected the US and world economies.

2. The advantages of a dummy variable model

215. There are two methods that are commonly used to estimate overcharges, each of which seeks to compare prices in the alleged cartel period to those in a non-cartel period, after controlling for relevant economic variables:

- The dummy variable model uses data from both the alleged cartel period and the non-cartel period to estimate the relationship between price, economic factors, and a dummy variable for the alleged cartel period, which measures how much

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195 *Hausman Report,* ¶31.

higher prices were in the alleged cartel period relative to the non-cartel period, after controlling for the other economic factors.

- The prediction model uses data from only the benchmark period to estimate the relationship between price and economic factors. It then uses the estimated relationship as a basis to predict what prices would have been during the alleged cartel period but-for the alleged cartel, with the gap between actual prices and the estimated but-for prices assumed to represent cartel effects.

In my analysis, I rely on the dummy variable approach, for the reasons discussed below.

216. Per the discussion above, valid application of either the dummy variable approach or the prediction model approach is based on an assumption of model stability, although the implications of such an assumption vary between the two models. The dummy variable model assumes that the relationship between price and the economic factors (other than the cartel dummy) is the same during the cartel period and during the non-cartel period. Although potentially a restrictive assumption—which generally invalidates the approach if violated—this assumption is testable. In particular, one can estimate the same economic model over the cartel and non-cartel subsamples of the available data and test whether the model's parameters are statistically significantly different in the two time periods. If the assumption of model stability is not rejected, then there is a statistical basis to rely on the results from the dummy variable model to estimate the cartel effect on price.

217. The prediction model is based on a maintained assumption that the relationship between price and economic variables that is estimated for the benchmark period alone *would have held in the alleged cartel period* but-for the alleged cartel. There is, of course, no way to test this assumption directly because we never observe the industry operating during the cartel period without the cartel, but it may be a reasonable assumption in some settings, especially where similar economic forces would have been acting in each period (i.e. the non-cartel period and the cartel period in the absence of the cartel) and where one has controlled for the effects of the various economic forces.

218. The prediction model assumes that *all* changes in the relationship between price and economic factors between the benchmark and cartel periods must be due to the cartel

and not to other changes in the marketplace. If this assumption fails, then the prediction method will yield unreliable results.[196] To illustrate this idea, imagine I estimated a relationship between height and weight, using a sample of NBA players. I could use this estimated relationship to predict the weight of new players based on their observed height, and if the model were built with care, it potentially could give reliable and accurate predictions of the weights of these new players. However, this model would not give reliable predictions of the weights for, say, sumo wrestlers—the characteristics of that population are so different from the population used to construct the model that the prediction model would be totally unreliable.

219. Although the sumo wrestler example is extreme, the insight of the example is fundamental to understanding why pure prediction models may be unreliable to use in this case. As demonstrated throughout this report, both the pre- and post-alleged-cartel period are different from the alleged cartel period in a number of ways. For example, the pre-2000 period is characterized by very poor quality of available data,[197] the recent entry of many Taiwanese panel producers, the near complete absence of television or mobile phone panels, and substantial competitive pressure from CRT panels in the monitor application. In contrast, the post-2006 period coincides with the introduction of the iPhone and enormous growth in smart phones, substantial shifts into widescreen and HD formats, as well as a global financial crisis and recession.[198] Differences in the economic relationships in the alleged cartel period and the benchmark period periods can make a prediction model unreliable, especially a prediction model that relies on only a few economic variables, a reliance that may be dictated by the limited amount of data in the

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196 *See Hausman Report,* ¶31.

197 For example, many firms that had sales prior to 2000 were not able to provide historical data going this far back: Chi Mei's sales data starts in January 2000, LGD's sales data starts in January 2001, and AUO's sales data starts in September 2001.

198 Expert Report of Keith Mallinson, February 20, 2012 (hereinafter *Mallinson Report*), ¶39 and Exhibit 8. For example, according to Defendants' transaction data, in 2001, more than 99 percent of panels had (non-widescreen) XGA or SXGA displays. In 2006 (at the end of the alleged cartel period), XGA and SXGA displays still made up 83 percent of monitor panels. However, by 2009, only 17 percent of monitor panels had XGA or XSGA displays. Similarly, there were few full HD (HD1080) TV panels during the alleged conspiracy (less than 2 percent by 2006). By 2009, however, almost a third of TV panels sold had HD1080 resolution or higher.

benchmark period. One cannot simply assume—as the pure prediction model does—that any difference between the actual price and the price predicted by the prediction model are due to effects of the alleged cartel rather than the other large changes in the TFT-LCD industry and the broader economy without running substantial risk of making an error.

220. As explained by Dr. Hausman:[199]

> Because of the likely structural instability arising from the severe recession, the "backcast" or "prediction" model approach is unlikely to yield accurate estimates of overcharges from the alleged cartel: There is no basis to assume that gaps between predicted and actual price represent cartel effects rather than other changes. In this situation the "dummy variable" approach to damage estimation (with appropriate tests to ensure the model is reasonably stable) will likely be superior to the backcast or prediction method.

221. The prediction method has another disadvantage when the time period of the benchmark period is short. In that case, there will not be much data to use to estimate the model and therefore the model will be poorly estimated, thereby providing unreliable predictions of price in the alleged cartel period.

222. The current context provides a specific example of the dangers of using the prediction method. In particular, a prediction model would be based on a very limited amount of data from outside the alleged cartel period—given the unreliability of data from before 2000 and from 2009,[200] there are effectively eight quarters of benchmark period data (2007-2008) on which to estimate a model. Estimating an econometric model on such limited data makes it more difficult to obtain precise, reliable estimates of the underlying economic relationships.[201] For example, if I estimate the econometric model described in the remainder of this section using only data for 2007-2008, I get implausibly low effects of cost on price for many applications, implying that a 10 percent increase in small panel costs, for example, would lead to

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199 *Hausman Report,* ¶31.

200 For example, available data from Defendants includes no AUO sales data for 2009 and no AUO or Samsung cost data for 2009.

201 *See* Paul E. Godek (2011), "Time Series Models for Estimating Economic Damages in Antitrust (and Other) Litigation: The Relative Merits of Predictive versus Dummy-Variable Approaches," *CPI Antitrust Chronicle*, (1):1-7 at 4.

only 0.18 percent increase in small panel prices, with corresponding figures for TV and mobile panels of 1.5 percent and 1.6 percent respectively.[202] Such a low effect of cost on price seems implausible and is undoubtedly the result of having to use a very limited amount of data to obtain an estimate. If I then followed the prediction method and used this post-cartel period cost elasticity to project back to determine what prices would have been during the alleged cartel period (but-for the cartel), I would likely predict that but-for prices would not have been much higher in the early part of the alleged cartel period, despite the fact that costs were much higher in that early period (*see* discussion in Section II, above). In that case, I would conclude mistakenly that actual prices were much higher than but-for prices—and thus that there was a large overcharge—solely due to the excessively low cost elasticity estimated on the post-cartel period.

223. Hence, in my modeling, I rely on dummy variable models. And I rely only on econometric models for applications and time periods that pass appropriate tests for structural stability—meaning that I cannot reject the hypothesis that the economic relationships among the economic variables captured in the model are the same across the benchmark and alleged-cartel periods (with the obvious exception of the cartel effect).

224. Finally, I note that a *structurally stable* dummy variable model has one additional advantage over a prediction model in this case: It more easily incorporates lagged values of prices as explanatory variables, as is important to capture the evolution of prices. To make use of such lagged prices, a prediction model would need "clean" prices from a period before the alleged cartel in order to "start up" the dynamic prediction process. However, in many cases, particular panels were not sold prior to the beginning of the cartel. For these panels, the prediction method alone

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[202] These estimates refer to my model specification without a panel age measure (*see* discussion below). For monitor panels, the estimate for the 2007-2008 period is also much lower than for the 2000-2006 period (elasticity of price with respect to cost of only 0.45 vs. 0.97 for the 2000-2006 period). For notebook panels, the estimated elasticity of price with respect to cost is 1.27 for the 2007-2008 period vs. lower figures for the 2000-2006 period (0.74) and the full 2000-2008 period (0.83), again showing that using data on the post-period alone may lead to estimates that diverge sharply from estimates based on longer time series.

cannot be used to construct but-for prices to compute the cartel effect, whereas the dummy variable model permits direct estimates of the magnitude of the long-run cartel effect.

D. An Econometric Model of TFT-LCD Panel Prices

225. In order to build a reasonable econometric model of overcharges, I conform to a number of standards. These standards are in agreement with those expressed by Dr. Hausman in his report.[203] In particular:

- I use disaggregated data, rather than a price index, to avoid confounding any cartel effects with changes in the product mix over time. As Dr. Hausman explains, price indices can be sensitive to changing mix, to new product introductions, and to old product discontinuations. Giving the rapid technological change and rapidly changing product mix in this industry, this is a serious concern that would need to be carefully addressed in a model using price indices.

- I include fixed effects to control for the significant heterogeneity in products—in terms of the size of the panels, the resolution, the application the panel will be used for, and the defendant selling the panel.

- I estimate dynamic models—meaning models that incorporate the effect of lagged prices and lagged explanatory variables—to account for the adjustment of prices to changing economic conditions and the inherent dynamics of demand and supply decisions in this market. Given the facts that costs can decline through time because of learning-by-doing, that consumers can shift their purchases in time (*i.e.,* delay purchasing if prices are high or accelerate purchasing decisions if prices are particularly low at some point in time), and that new products and new technology can alter the relative desirability of a product, prices tend to be correlated through time, and so careful models should incorporate these intertemporal connections.

- I use appropriate econometric methods to address potential issues of endogeneity with the lagged dependent variables and the potential errors-in-variables problems

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203 *Hausman Report*, ¶31.

with measures of cost. I use econometric methods that correct for the possibility of inconsistent estimates (that is, econometric estimates of parameters that are inaccurate, even in very large samples). These methods are discussed more fully below.

226. Consistent with these standards, I build an econometric model with the following features:

- It is a reduced form pricing model that relates prices to economic variables that measure cost and demand factors;
- It is a dynamic model that incorporates the dynamic responses of prices to both short run and longer run changes in these economic variables;
- It takes account of the heterogeneity in the products produced by the defendants—accounting for the heterogeneity in applications, size of the panels, resolution of the panels, and the manufacturer of the panel—including the use of application-size-resolution-manufacturer fixed effects;
- It is run separately by panel application including the use of different sets of explanatory factors for different applications to reflect different demand and cost drivers.

227. Most importantly, after running my model for each application to allow for different underlying models.

1. Reduced form dummy variable model

228. The basic methodology I use to estimate overcharges on TFT-LCD panel purchases is a dummy variable version of a reduced form price model. A reduced form price model is an econometric model of the market relationship between prices paid, for example, for TFT-LCD panels and the factors that shift demand and cost. The reduced form approach directly estimates the relationship between all these economic factors and the resulting prices in a single econometric relationship, rather than separately modeling the demand and supply relationships that simultaneously determine price and quantity.

2. Explanatory variables

229. My model characterizes prices as a function of the following explanatory variables (along with a dummy variable to capture cartel effects):

230. First, I include a measure of the unit cost of production for a given manufacturer/panel/quarter (as well as lagged values of this cost). This information is available from several, but not all, of the defendants. When it is available, I use the actual costs as recorded by the defendants. For defendant/panel/quarters in which cost information is not available, I impute the cost, using a method described more fully below.

231. In addition to the unit cost of production, explanatory variables include the following (or functions of the following):

- Shipping price index as well as a lag of this index (included as an additional cost in addition to production costs);[204]
- U.S. consumption expenditures on computers, included as a measure of the demand for computers which can impact the demand for panels for both monitor and notebook applications;
- The number of mobile phones sold worldwide, included as an additional measure of the demand for TFT-LCD panels for mobile phone applications;
- In some specifications, age of the product in its life-cycle, measured as the number of quarters since the product was introduced;
- In sensitivity runs, I consider additional cost and demand controls to show that my results are reasonably stable.

3. Dynamic pricing model

232. I account for the dynamics of price determination for TFT panels by estimating models that allow for flexible patterns of price changes in response to changing economic condition. These models start from a basic economic insight: in the long run, equilibrium prices are determined by cost, demand, and competitive conditions, but short run prices

[204] Details on these control variables contained in my backup materials.

can deviate from these long run equilibrium levels due to shocks to costs, demand and other economic factors. The prices that we actually observe in the market reflect both the tendency of market forces to lead prices to adjust toward a long-run equilibrium and also the tendency of market forces to cause prices to respond to short-run shocks. The models that I use allow prices to adjust to short-run changes in cost and demand conditions, and, at the same time allow prices to adjust toward the long-run equilibrium relationship determined by long-run cost and demand conditions.

233. My dynamic model specifies the relationship between prices and cost and demand conditions in the following form[205]:

$$P_t = \gamma + \beta_1 P_{t-1} + \beta_2 X_t + \delta_1 \Delta P_{t-1} + \delta_2 \Delta X_t$$

where P_t is the natural logarithm of the price in time period t; X_t are a set of explanatory factors that affect prices; ΔP_{t-1} is last period's change in (log) price and ΔX_t is the change in the explanatory factors between last period and this period. The coefficients $\gamma,\ \beta_1,\ \beta_2,\ \delta_{1,}, and\ \ \delta_2$ are the economic parameters that I estimate, which together determine how prices respond to the economic factors that we can measure. When I implement this model, there will be several components to X_t (as listed above), and there is a separate component of β_2 corresponding to each of the components of X_t .

234. The interpretation of this model is as follows. The coefficients δ_1 and δ_2 measure how the prices respond to the changes, or shocks, in last period's prices and this period's shocks to the explanatory variables. The coefficient β_1 is a measure of how quickly prices adjust over time to changes in economic variables. That is, if β_1 is close to 1 then prices will tend to adjust more slowly over time to changes in underlying economic factors than if β_1 is close to zero. The coefficient(s) β_2 measure how prices respond to the levels of explanatory variables included in X_t .

235. Because the model is dynamic, prices respond immediately to the levels of X_t but future prices are also affected by the lagged values of prices. A useful way to think about how changes in the level of X_t affect prices is to compute the long-run effect of a

205 In my base model, demand enters only contemporaneously.

permanent change in X_t on prices. To do this, note that a permanent change in the explanatory variables will leave the shocks to those explanatory variables unchanged and will (so long as β_1 is less than 1) lead to a permanent change in price, so we have

$$P = \beta_1 P + \beta_2 X$$

or

$$P = \frac{\beta_2 X}{1 - \beta_1}$$

implying that the impact of a permanent change in X on price is given by $\beta_2/(1 - \beta_1)$. In particular, if one of the explanatory variables included in the model is a dummy variable that indicates the presence of a cartel, then the long-run impact of the cartel on (log) prices would be measured by the coefficient on the cartel dummy variable divided by $(1 - \beta_1)$.

4. Heterogeneity across panels

236. To account for the heterogeneity in TFT-LCD products, I incorporate two key features in my model. First, I estimate the model separately by application (including monitors, notebooks, TVs, and mobile phones). Demand factors may differ across applications, so the appropriate control variables will be different. Competitive factors will also vary: For example, monitor applications competed with CRT panels during part of this period; TFT-LCD panels for TVs competed with CRT and Plasma panels; notebook computers may compete with desktop models, but have no good substitutes for screens.[206]

237. Second, I compute prices for specific detailed products that vary by the key characteristics that can affect price. For each application, I have identified key products, defined by the size of the panel and the display standard (or resolution) of the panel. For example, 17” SXGA panels for monitors would be a key product, as they account for the largest revenue among all size-resolution combinations for monitors. I include in my estimation those key products that collectively account for at least 95 percent of the

206 Note that changes in the degree of competition with CRT and plasma may be a source of model instability, particularly for TV and monitor models.

revenue in my database for each of the four application groups. I find that a total of 24 specific products account for more than 95 percent of the total revenue of all panels sold for monitors in the defendants data. Similarly, 30 products account for more than 95 percent of the revenue of all products sold for notebook computers; 32 products for TV panel sales, and 72 products for mobile phone applications. The products not included in the top 95 percent of revenue account collectively for a relatively small amount of the total revenue.[207]

238. For each of these key products, I use manufacturer-application-size-resolution as the main unit of observation for my models. For example, for the key product 17" SXGA monitor panels, I find that there are 7 distinct products in the database corresponding to the 7 defendants who supply that particular type of panel, and my model includes an observation for each quarter in which each included manufacturer-application-size-resolution combination is observed.

E. ESTIMATION DETAILS

1. Baseline model

239. To implement the modeling approach described in part C, I use a baseline regression equation for each application that relates the price for each product i in each quarter t $(P_{i,t})$ to explanatory variables, using the dynamic model described above:

$$P_{i,t} = \gamma_i + \beta_1 P_{i,t-1} + \beta_2 X_{i,t} + \delta_1 \Delta P_{i,t-1} + \delta_2 \Delta X_{i,t}$$

Note that each of the products has its own value of γ_i, meaning that the level of prices can vary across products. This product specific parameter is called a fixed effect.

207 Sales not included in the dataset (the bottom 5 percent of revenue for each application) account for \$1.8 billion for monitors between 2000 and 2008; \$1.6 billion for notebooks; \$1.1 billion for TVs; and \$618 million for mobile devices. When combined, these dropped sales account for \$5 billion between 2000 and 2008, while sales included in the cleaned dataset total around \$159 billion.

240. I can rewrite this as a pooled time-series cross-section regression model,[208] which relates current price to prices in the previous two periods and the values of the other economic factors—measured by $X_{i,t-1}$—in the previous two quarters:

$$P_{i,t} = \gamma_i + (\beta_1 + \delta_1)P_{i,t-1} + (\beta_2 + \delta_2)X_{i,t} - \delta_1 P_{i,t-2} - \delta_2 X_{i,t-1}.$$

241. The economic variables that I include in the set of factors denoted by $X_{i,t}$ vary by application. My baseline model includes: a cartel dummy variable(s), natural log of product cost, natural log of shipping costs, natural log of an application-specific demand measure (for example, for panels used for mobile devices, I use the number of mobile phones sold worldwide), and (in some specifications) the age of the product in its life-cycle, measured as the number of quarters since the product was introduced.

2. Data

242. To estimate the model, I rely on the detailed transactions data provided by AUO, CMO, CPT, Epson, Hannstar, Hitachi, LGD, Samsung, Sharp and Toshiba. Although the dataset that I have constructed based on these transactions spans the period from the beginning of 1999 through the end of 2009, as described above, the data for 1999 and 2009 are both missing sales and cost data from several of the defendants who provided it for other years, so I use data from 2000 to 2008.

243. I construct quarterly prices and costs for each of these manufacturer-application-size-display standard combinations. In doing so, I omit transactions that have extreme prices, deleting the top and bottom 1 percent of prices by application/year combination, as well as transactions that appear to be miscoded or mis-recorded.[209] This process yields a rich and detailed set of prices and costs for a detailed and heterogeneous set of products.

208 Such models are usually called panel data models. Because of the confusion that can arise from using "panel" in two different ways, I will refer to these as pooled models or pooled time-series cross-section models.

209 The defendant transaction data that I use excludes internal sales, affiliate sales and sales between defendants, since these transactions might not be affected by cartel price effects. I also exclude from estimation panel / quarter combinations with less than $10,000 in revenue.

244. About one-third of the application/size/resolution/defendant observations are missing information on cost. However, these observations account for only approximately 15 percent of the revenue in my dataset. I employ standard statistical method to deal with this problem of missing data, by imputing the values of the cost for those observations where it is missing.[210]

3. Use of instrumental variables

(a) Endogeneity of lagged price

245. In models like mine—pooled time-series cross-section models with lagged dependent variables and relatively short time-series—a potential problem in using standard estimation methods is that the correlation between the lagged endogenous variables (here, lagged prices) and the fixed effects term may lead to biased and inconsistent parameter estimates.[211] To address this potential problem, I use the estimation method generally referred to as the Arellano-Bond estimator.[212] The Arellano-Bond estimator uses an instrumental variables methodology, using lags of prices as instruments, to address the correlation between the lagged price terms and the fixed effects. This provides consistent estimates of the key parameters of the model even for short time series.

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210 For a discussion of the use of imputation methods to deal with missing data, see Roderick J. A. Little and Donald D. Rubin (1987), *Statistical Analysis with Missing Data*, Wiley-Interscience. I use the "impute" command in STATA to do this imputation, using information on the defendant, the time period and the characteristics of the panels—application/size/resolution—to construct these imputations.

211 *See, e.g.*, Cheng Hsiao (2003), *Analysis of Panel Data*, Cambridge University Press, 2nd ed.; Manuel Arellano and Bo Honore (2001), "Panel Data Models: Some Recent Developments," in *Handbook of Econometrics*, James J. Heckman and Edward Leamer, eds., 5:3229-3296.

212 *See, e.g.,* Manuel Arellano and Bo Honore (2001), "Panel Data Models: Some Recent Developments," in *Handbook of Econometrics*, James J. Heckman and Edward Leamer, eds., 5:3229-3296.

246. To estimate this dynamic model with pooled data, I use the two step version of the Arellano-Bond estimator.[213] This version updates the weights used to construct optimal combinations of moment conditions and leads to improved estimator performance.

(b) Measurement errors in defendants' cost data

247. As noted above, the Defendants' cost data may be a noisy measure of marginal costs, potentially creating an econometric issue due to measurement error.[214] If this issue is not addressed correctly, it could lead to unreliable estimates of my econometric models, particularly the cost coefficient, due to correlation between the measured cost variable and the error term in my regression equation.[215] Note that, typically, errors-in-variables biases the coefficient on the variable measured with error, in this case cost, downward. Furthermore, if costs are positively correlated with the cartel dummy (because the costs were higher during the alleged cartel period) this will tend to result in coefficients on the cartel dummy that are biased upward. That is, errors-in-variables, if uncorrected, could result in an overestimate of the cartel impact on prices in this case.

248. To address the measurement error in cost, I use an instrumental variables strategy to address the potential correlation between the cost variables and the error term in my models. Following the work of Griliches and Hausman, I have used lagged values of the measured costs as instrumental variables.[216]

4. Bootstrap

249. Under my estimation strategy, estimated standard errors on my parameter estimates may not be reliable in small samples. To get more accurate standard errors and to assess the performance of my estimation strategy, I use a methodology known as the

213 In particular, I use the xtabond command in the Stata software package. Details of the estimation are available in my backup.

214 *See Hausman Report*, ¶18.

215 Zvi Griliches and Jerry A. Hausman (1986), "Errors in Variables in Panel Data," *Journal of Econometrics*, 31:93-118.

216 *Ibid*.

bootstrap.[217] I implement the bootstrap by resampling from the products within a category.[218] That is, I construct a random sample (with replacement) of products and replicate my econometric analysis on this sample. I repeat this procedure many times. This bootstrap procedure results in a large number of different values for the parameters I estimate and the cartel overcharges that I calculate. The distribution of these bootstrapped parameters and bootstrapped overcharges gives me reliable estimates of the variability (standard errors) of my parameter estimates and my computed overcharges. In fact, the bootstrap procedure will often outperform analytical methods for computing standard errors.[219]

F. Results on Stability and Model Performance

1. Model Stability

250. To assess in which cases my estimated model is reasonably stable—meaning that it finds reasonably stable relationships between price and the explanatory variables—I test whether coefficients estimated in the alleged cartel period and non-cartel period are sufficiently different to reject a hypothesis of common parameters across the time periods. To do so, I proceed as follows.

- First, I estimate the model for five possible application groupings—monitor panels, notebook computer panels, TV panels, mobile phone panels, and all small panels—and for the 2000-2008 time period. In each case, I split the sample into

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217 *See, e.g.,* Peter Hall (1992), *The Bootstrap and Edgeworth Expansion*, Springer-Verlag, New York; Joel L. Horowitz (2001), "The Bootstrap," in *Handbook of Econometrics*, James J. Heckman and Edward Leamer, eds., 5:3159–3228 (hereinafter*, Horowitz*).

218 Since the Arellano-Bond procedure averages over cross-sectional units, resampling cross-sections is the appropriate way to resample. Another way to think of this is that there may be time series dependence in the data, beyond what is included in the dynamic model. In that case, the bootstrap methodology should "block" on the time dimension (*see Horowitz* at 3188). Given that the time dimension is relatively short and that there is a substantial amount of cross-sectional variation, with a large number of products for each application, treating each product as a unit of observation for the bootstrap aligns my resampling with the logic of the Arellano-Bond estimator and designs the bootstrap to take into account any time series dependence in the data.

219 For example, *Horowitz* at 3161 ("the bootstrap is often more accurate in finite samples than first-order asymptotic approximations").

two time periods—the years up through 2006 and the years after 2006—and I estimate all parameters separately for the two time periods.[220] I then compute the difference in each parameter between the two time periods.

- Second, in order to obtain an estimate of the variance-covariance matrix of these differences, which I need to test whether they are jointly statistically significantly different from zero, I use the bootstrap, described above. In particular, I run 1000 bootstrap iterations, in each case obtaining an estimate of the difference between all parameters, and I use this vector of computed differences to estimate the variance-covariance matrix of the differences.

- Finally, using the differences estimated on the full sample and the variance-covariance matrix estimated from the bootstrap procedure, I conduct a standard Wald test of parameter equality.

251. The test for stability is rejected for the following three applications: monitor panels, TV panels, and all small panels combined. In each case, this result is not surprising: an aggregated category such as all small panels combined likely reflects a changing mix of products over time; TVs were a new and rapidly evolving product over the time period (see Section II), and monitors faced a changing degree of competition from CRT panels over the time period (see Section II). *The implication is that the stability assumption—one of the conditions required to obtain reliable overcharge estimates using the dummy variable method—is not met for these applications, so I do not use them in my analysis.*

252. However, model stability is not rejected for mobile phone panels, as well as for notebook panels for the 2000-2008 (and 2003-2008) period. However, I note that there were relatively few sales of mobile phones prior to 2003 so I use the 2003-2008 period to estimate results for mobile phones.[221] For notebook computers, I report results based on

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220 I also look at the 2001-2008, 2002-2008, 2003-2008, 2004-2008 time periods. Again, I test for stability in the years through 2006 versus the years after.

221 The model is structurally stable over the 2003-2008 period. The results that I report here for mobile phones are basically the same if instead one estimated the model for mobile phones over the 2000- 2008 period. Estimating the mobile phone model starting in 2000

estimates over the 2000- 2008 period. I also report results for the notebook model estimated over the period 2003-2008 because, as I soon explain, the notebook model produces a zero or negative estimate of cartel overcharges when one uses the 2000-2008 time period to estimate the model but a positive estimate of cartel overcharge when one uses 2003 to 2008. In neither case is it statistically significant.[222]

2. Coefficient Estimates

253. Results for my four base notebook models are presented in Table IX-2 below. Results for the two base mobile phone models are presented in Table IX-3. I estimate these models using the standard dummy variable approach, estimating the model on the full time period, with the "alleged conspiracy dummy" taking a value of one through 2006 and zero after 2006.

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leads to a very small decrease in my estimate of cartel overcharge and thus does not change my conclusions of no large cartel overcharges.

222 I have run tests for structural stability for all the applications over various time periods. The mobile phone model is structurally stable. The notebook model is structurally stable for the periods I report in the text but not for other periods. The models for the other applications are not structurally stable over any period I tested.

Table IX-2: Notebook Base Models

VARIABLES	Notebooks (2000-2008)	Notebooks (2000-2008) Add Panel Age	Notebooks (2003-2008)	Notebooks (2003-2008) Add Panel Age
Alleged Conspiracy Dummy	-.00021	-.00481	.00433	.01166
	[.01646]	[.01584]	[.01744]	[.0156]
L1.Log(Price)	.60323**	.44297**	.41092**	.42142**
	[.09448]	[.08905]	[.07546]	[.06671]
L2.Log(Price)	-.10952	-.1106**	-.16527**	-.08032
	[.06841]	[.05035]	[.05776]	[.05173]
Log(Unit Cost)	.4015**	.14073	.87237**	.20179
	[.15266]	[.08754]	[.16458]	[.20175]
L1.Log(Unit Cost)	.02061	-.1366	-.01389	-.29566*
	[.08155]	[.08601]	[.16633]	[.16599]
Log(Shipping Cost)	.0797**	.02064	.08429**	.03453**
	[.01433]	[.01265]	[.01581]	[.01372]
L1.Log(Shipping Cost)	-.02983	.07679**	.01688	.09361**
	[.01969]	[.01855]	[.02063]	[.0207]
Log(U.S. Consumption PC)	-.14957	1.54772**	-.08644	.99891**
	[.20885]	[.23441]	[.26423]	[.2915]
Panel Age		-.05883**		-.05391**
		[.00557]		[.0106]
Constant	1.66807	-12.23194**	-.28704	-6.35824**
	[2.39803]	[2.30969]	[3.26358]	[2.92167]
Observations	1,443	1,443	1,239	1,239
Number of group_id	104	104	100	100
Sargan Test Statistic	98.96	100.61	83.93	84.69
P-value	0.62	0.58	0.09	0.08
Long-Run Cost Effect	0.83	0.01	1.16	-0.14

Bootstrapped standard errors in brackets
** p<0.05, * p<0.1

Table IX-3: Mobile Phone Base Models

VARIABLES	Mobile Devices (2003-2008)	Mobile Devices (2003-2008) Add Panel Age
Alleged Conspiracy Dummy	.01307	.01506
	[.03175]	[.03273]
L1.Log(Price)	.23095**	.19334*
	[.08945]	[.10349]
L2.Log(Price)	.05748	.0349
	[.03785]	[.04252]
Log(Unit Cost)	.38216**	.36615**
	[.10838]	[.12562]
L1.Log(Unit Cost)	-.09043	-.11753*
	[.0662]	[.06159]
Log(Shipping Cost)	-.00401	-.01246
	[.01628]	[.01448]
L1.Log(Shipping Cost)	.05322*	.07313**
	[.02844]	[.02546]
Log(Mobile Shipments)	-.48009**	-.39803**
	[.11025]	[.12219]
Panel Age		-.01225
		[.01253]
Constant	4.07381**	3.96505**
	[.86563]	[.88033]
Observations	991	991
Number of group_id	105	105
Sargan Test Statistic	78.64	77.73
P-value	0.18	0.20
Long-Run Cost Effect	0.41	0.32

Bootstrapped standard errors in brackets
** p<0.05, * p<0.1

254. The estimated economic relationships are generally sensible. Looking at the 2000-2008 notebook model (without panel age control), the lag of price, unit costs, and shipping costs all have statistically significant effects on price, the implied long run cost effect (the elasticity of price with respect to a change in cost is 0.83), implying that a 1 percent increase in cost leads to a slightly smaller than 1 percent increase in price, a not unreasonable result. Shipping costs and lagged prices also have positive effects on current prices. The level of computer expenditures has no statistically significant effect on prices, as is not surprising, as there is no reason to expect a long run relationship between the level of demand and price.

255. For the mobile phone regression without a panel age control, the results are similarly sensible. One difference is that the level of mobile phone shipments has a negative and significant long run effect on price, but this is not unreasonable to the extent that the mobile phone panel segment is newer than the notebook segment and thus may experience substantial learning by doing as mobile phone sales grow over time.[223]

256. In the models that add panel age, I obtain the expected negative sign for panel age (statistically significant in the notebook models) reflecting the decline in panel prices over their life-cycle. However, not surprisingly, adding panel age makes it more difficult to separately identify the cost effects since costs also tend to fall over a panel's lifecycle. Hence, in the notebook model, the long run cost effect falls to near-zero when the panel age control is added.

3. Testing Over-identifying Restrictions

257. As an additional specification test, I compute the Sargan statistic for testing the over-identifying restrictions. As Dr. Hausman has pointed out in his report, this is an important test to perform, to check that the model specification and the instrumental variables that I have used are appropriate.[224] As seen in Table IX-2 and Table IX-3, for all my base models, the test does not reject the over-identifying restrictions (the p-value is greater than 0.05) indicating that the model is well specified and the instrumental variables are appropriate.

G. RESULTS IMPLY SMALL, STATISTICALLY INSIGNIFICANT OVERCHARGES

1. Notebook and Mobile Panels

258. Table IX-4 gives the estimated long run cartel overcharge percentages based on each model's parameter estimates. As described above, I compute these overcharge percentages based on the alleged cartel dummy variable divided by one minus the sum of

223 The long run elasticity of price with respect to cost in the mobile phone regressions is smaller than I would have expected. I note that an understated effect of cost on price would likely push my estimated cartel overcharges upward, since costs were higher during the alleged cartel period than after.

224 *Hausman Report,* ¶13.

the lagged price terms.[225] By focusing attention on this long-run cartel overcharge percentage, I conservatively act as though the alleged cartel reached its long-run impact immediately, ignoring the fact that, according to the model, it would have taken time for the alleged cartel to reach full effect.

Table IX-4: Long Run Percentage Overcharge

	Mobile Devices (2003-2008)	Mobile Devices (2003-2008) Add Panel Age	Notebooks (2000-2008)	Notebooks (2000-2008) Add Panel Age	Notebooks (2003-2008)	Notebooks (2003-2008) Add Panel Age
Long Run % Overcharge*	1.8%	1.9%	0.0%	-0.7%	0.6%	1.8%
	[4.34%]	[4.09%]	[3.18%]	[2.33%]	[2.29%]	[2.29%]

* Bootstrapped standard errors in brackets.

259. *The most notable feature of these results is that, in none of my base models, for either notebook panels or mobile phones, is the estimated long run cartel effect even close to statistically significantly different from zero*. Put simply, to the extent that the alleged cartel had an effect on prices, it cannot be detected statistically with my model. The measured size of the cartel effects is so small as to be indistinguishable from random fluctuations in price.

260. To the extent that one uses my model to form an estimate of the magnitude of the alleged cartel's effect on prices (in spite of this statistical insignificance), then the range of estimates across my base runs provides the best information. As seen in the tables, the range of estimated cartel effects goes from -0.7 percent to 1.8 percent for notebook panels.[226] The average across these estimates is 0.4 percent, which I use as my base

225 To be precise, I take the anti-log of this function to yield a consistent estimate of the effect on level prices. Standard errors are computed via the bootstrap procedure; details are in my backup materials.

226 If , despite the lack of model stability, one were to use the 2000-2008 period for monitors and television panels , one would find a range of overcharges for monitor panels from 4.4 percent to 6.4 percent for monitors and from -3.3 percent to -6.6 percent for television panels depending on whether the equation specification includes panel age. If one uses these estimates to form a weighted average overcharge estimate for all large panels (using both the econometric models with and without the panel age control and using weights based on the Defendants sales revenue in the cartel period), one obtains an estimate of 1.4 percent for all large panels (*i.e.*, TV panels, monitor panels, and notebook panels).

estimate for notebook panels. The range across mobile panels is 1.8 percent to 1.9 percent, with an average of 1.9 percent, which I use as my base estimate for mobile panels.

2. Other Small Panels, Monitor Panels, and TV Panels

261. As noted above, my econometric model estimates are not stable over time for small panels, monitor panels, or TV panels, making these models as unreliable as a basis to predict alleged cartel effects. Instead, in my view, the best available evidence on these other panels comes from the evidence presented throughout this report, indicating that any overcharge was likely quite small.

262. To the extent one wishes to use my reliable econometric models as a basis to estimate cartel overcharges for these other panels:

- For other small panels, in my view the mobile phone estimate of 1.9 percent is the best proxy measure that can be formed from my model. However, based on my and my staff's review of the guilty pleas and the documents cited and produced by Plaintiff Experts, it appears that most allegations of communications are with regard to mobile phone panels, so I consider the 1.9 percent estimate to be a likely upper bound.

- For monitor panels, as I have established throughout this report (see Sections II through IV in particular), the record of communications and the observed pricing patterns indicate similarities with notebook panels. So I consider my 0.4 percent estimate for notebooks to be the best available proxy from my econometric models for the cartel overcharge percentage on monitor panels. However, given that monitor panels faced non-LCD competition from CRT panels throughout much of the alleged cartel period, while notebook panels did not face any significant non-LCD competition (see Section II), I consider this to be a likely upper bound.

- For TV panels, the relation between notebooks and TV panels is less tight than between notebooks and monitors, but if forced to use an econometric estimate to estimate cartel overcharges, I would use the 0.4 percent, based on notebook

panels, since both TV panels and notebooks were discussed at the Crystal Meetings. However, given the following:

- The more limited record of communication about TV panels at the Crystal Meetings and the greater dispersion of prices around discussed prices for TV panels compared to notebooks (See Section IV);
- The fact that TV LCD panels faced non-LCD competition from plasma and CRT panels (see Section II), and
- The fact that a larger percentage of TV panels are sold internally or to related firms than for notebook panels, with vertical integration known to hinder successful price elevation by cartels (see Section V),[227]

I conclude that the notebook estimate is a likely upper bound for any TV overcharge.

H. RESULTS ARE ROBUST

263. Finally, to confirm that my results on the estimated cartel overcharge are not sensitive to small changes—including those that I have shown have large effects on the results of various Plaintiff Experts—I re-run my base models (all four notebook panel models and both mobile phone models) making the following changes:

- I add the first lag of my industry demand measure (US PC consumption, mobile phone shipments) as an explanatory variable (in addition to the contemporaneous control in my base model). Having both the contemporaneous level and the first lag is equivalent to allowing prices to react to both levels and changes in this variable.
- I drop the lag of shipping costs as an explanatory variable (so that shipping costs are treated symmetrically to the demand variable);
- I add a second lag of the cost variable as an explanatory variable;[228]

227 According to Defendants' transactions data, approximately 35 percent of Defendants' revenue for TV panels was due to sales to internal or related entities, whereas only approximately 10 percent of sales for Notebook and Monitor panels were to internal or related entities.

- I add an additional cost control, in levels and lagged, computed as a combined index of the largest TFT-LCD panel input costs reported by DisplaySearch;[229]
- I add an additional demand control defined by total industrial production in G7 countries;
- I use a different instrumental variable structures for price and cost (including lags up to the fifth lag for both price and cost)
- I estimate my model weighting all observations by the total revenue for the specific panel.

264. Table IX-5 lists the estimated long-run cartel overcharge percentage (defined as described above) for each of the models in Table IX-2 and Table IX-3, under each of these 7 alternative specifications. The results are similar to the results reported earlier in showing no robust estimates of large overcharges.

Table IX-5: Long Run Percentage Overcharge: Sensitivity Runs

	Notebook				Mobile Devices	
	2000-2008		2003-2008		2003-2008	
	No Panel	Panel Age	No Panel	Panel Age	No Panel	Panel Age
Add Lag of Demand*	-7.1%	-1.4%	0.0%	1.9%	1.9%	2.1%
Drop Lag of Shipping Cost	2.0%	-4.1%	-0.2%	-1.2%	-2.3%	-2.3%
Add Second Lag of Defendants' Cost	1.1%	0.7%	-0.1%	1.4%	-0.2%	-0.1%
Add Display Search Cost	-4.9%	-0.2%	-0.7%	5.6%	-0.4%	-5.7%
Add Industrial Production, G7	-0.2%	-1.4%	0.3%	1.2%	0.5%	1.7%
Longer Lag Structure	0.3%	0.2%	2.9%	1.5%	-0.3%	0.5%
Weighted	-4.6%	-2.6%	2.5%	3.5%	-5.9%	-6.1%

*US PC consumption for NB; Mobile Shipments for MD

X. CONCLUSIONS

265 My conclusions in this matter are summarized as follows:

- There are at least three categories of TFT-LCD panels that are distinct in their characteristics, exhibit notably different price paths, and have markedly different documentary records of communications among Defendants.

228 Dr. Hausman indicates that adding additional lags of cost as explanatory variables may help to resolve issues with measurement error in cost. (*Hausman Report*, ¶20.)

229 Details of the computation provided with my backup material.

  - Large panels used for TVs;
  - Panels used for computer monitors and notebook computers;
  - Small panels used for mobile phones and other small devices.

- The documentary record of communications among defendants cannot establish the existence of significant overcharges. Rather, a careful study of TFT-LCD industry conditions and empirical evidence on prices, costs, and margins is required.

- The TFT-LCD industry and the alleged cartel exhibit many economic characteristics known to hinder cartel success in elevating prices significantly.

- Straightforward empirical evidence on TFT-LCD prices, quantities, and capacity utilization point to non-cartel-based, demand-side explanations for periods of rising prices (price humps).

- With regard to econometric overcharge models, I conclude:

  - Dr. Rao's model is too unreliable to support any inference of large positive overcharges;

  - In my own, more appropriate econometric modeling, I find that reliable econometric models of overcharges can be constructed only for mobile phone panels and notebook panels, not for all small panels combined, monitor panels, or TV panels;

  - None of my preferred econometric models finds a statistically significant effect of the alleged cartel on prices. To the extent the model estimates an overcharge, it is too small to be distinguished statistically from random price fluctuation;

  - If I am asked to assume the existence of a successful cartel and to use an econometric model to form the best available prediction of the cartel's effect on prices, my model yields an overcharge prediction of approximately 0.4% for notebook computers;

- If I am asked to provide an estimated overcharge for monitor panels, my main response is that I do not have a reliable econometric model for those panels on which to base such an estimate. However, I consider my overcharge estimate for notebook computers to be the best available estimate for monitor panels.

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I hereby swear to the foregoing under penalty of perjury. Executed this 23rd day of February, 2012, in Washington, District of Columbia.

Dennis W. Carlton

Dennis W. Carlton, Ph.D.